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34

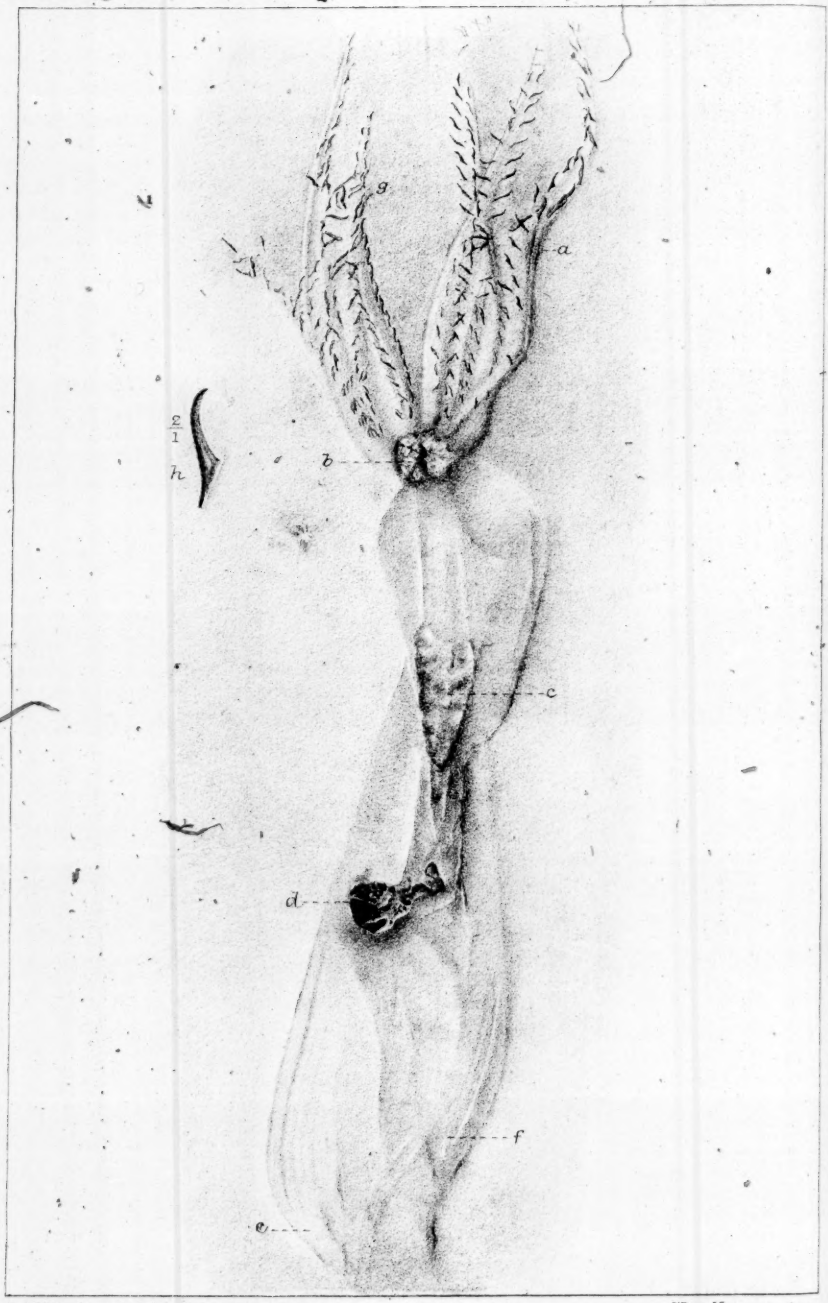
LIST OF PLATES.

PLATE		FACING PAGE
I.	*Acanthoteuthis speciosa*, Münster	1
II.	The Old Pump, Cultra, Co. Down	62
III.	High Stacks, Flamborough Head	109
IV.	The Whin Sill at Cullernose, Northumberland	109
V.	*Stereosternum tumidum*, Cope	145
VI.	*Acanthonautilus bispinosus*, A. H. Foord	149
VII.	Portrait of Dr. G. M. Dawson	193
VIII.	*Estheriïna*, gen. nov.	195
IX.	Restored Skeleton of *Æpyornis Hildebrandti*, Burckhardt	241
X.	South American and other Estheriæ	289
XI.	Fossil Entomostraca from South America	289
XII.	*Ceraterpeton Galvani*, Huxley	294
XIII.	Stem of new Fossil Cycad, *Cycadeoidea gigantea*, Seward	314
XIV.	*Cycadeoidea gigantea*	314
XV.	A new Silurian Crinoid from Melbourne, Victoria	338
XVI.	Junction of amygdaloid basalt with shales and limestones, near Kinghorn, Fife	370
XVII.	Views of Dùn Beag and Dùn Mòr, Sanday	370
XVIII.	Portrait of Harry Page Woodward	385
XIX.	Skull of Male of *Protoceras celer*, Marsh	433
XX.	Portrait of the Rev. P. B. Brodie	481
XXI.	Map of the Pleistocene Geology of Western New York	529

LIST OF ILLUSTRATIONS IN THE TEXT.

PAGE

Belemnoteuthis antiqua, Pearce 3
Map of the District in which the Nino-Owari Earthquake originated . . . 24
" " " " " " . . . 26
Section in Culvert north of Lambert Hill, Hucknall Torkard 50
Section of the Cutting through Normanton Hills 53
Cutting south-east of Stocking Farm, near Leicester 55
Protosiphon Kempanum, Matthew, n.sp. 70
Section at Charwelton, Northamptonshire 100
Sections east of Hill Farm, Radstone, Northamptonshire 103
Section in Quarry, Zinal, Canton Valais 111
Millericrinus recubariensis, Crema, sp. 118
Portrait of Dr. Bowerbank 135
Atlas and Axis of *Æpyornis* 243
Pelvis of *Æpyornis Hildebrandti*, Burckhardt 248
Endoceras Burchardii, Dewitz 252
Section of Strata at Handley's Pit, Lincoln 254
Gephyroceras intumescens, Beyr., and *Tornoceras simplex*, Von Buch . . . 281
Brancoceras Ixion, J. Hall 282
Pericyclus Doohylensis and *Glyphioceras Hispanicum*, Foord and Crick . . . 283
Pronorites cyclolobus, J. Phill., and *Agathiceras Suessii*, Gem. 284
Hill Section to show the Formation of Terraced Slopes 302
Apical Bud of *Cycadeoidea gigantea*, Seward 319
Volcanic Ash, Neilston, Renfrewshire 336
Alectryonia amor, D'Orbigny 413
Cranium of *Dinoceras mirabile*, Marsh 434
Cranium of *Protoceras celer*, Marsh 438
Section in Pit by spinny, north-west of Thorpe Limekiln, Norwich 490
Section near Surlingham St. Mary, near Norwich 492
Section in Pit at Poringland, Norfolk 493
Section in Chalk-pit, Claydon 494
Section in Cove opposite Carrigaghalia 507
Section in Cliffs, west side of Tramore Bay 508
Section at Newtown Cove 510
Left Dental Plate of *Ceratodus Kannemeyeri* 544
Figures of Faults to illustrate Mr. Lake's paper 545
" " " 546
" " " 547



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Acanthoteuthis speciosa, *Münster*.
Lithographic Stone. Eichstatt, Bavaria.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. IV.

No. I.—JANUARY, 1897.

ORIGINAL ARTICLES.

I.—On an example of *Acanthoteuthis speciosa*, Münster, from the Lithographic Stone, Eichstädt, Bavaria.

By G. C. Crick, F.G.S., of the British Museum (Natural History).

(PLATE I.)

THE genus *Acanthoteuthis* was founded by R. Wagner[1] and G. Münster upon small hooklets, sometimes isolated, sometimes associated with more or less complete remains of the animal, which are found in the Lithographic Stone of Bavaria. Münster characterized three species chiefly upon the form of these hooklets, viz, *A. speciosa*, *A. Férussacii*, and *A. Lichtensteinii*, and noticed the existence of a fourth. Subsequently Münster[2] referred to this genus also a number of forms based principally upon the shape of the body and upon the form of the internal shell, but most of these were afterwards separated by A. Wagner[3] as a new genus (*Plesioteuthis*). The genus *Acanthoteuthis* is therefore restricted to such forms as Münster described chiefly upon the form of the hooks. In two specimens of *A. speciosa* Münster says the mantle is preserved, and in it "the broad sword-like pen, devoid of any distinct ridges, is visible" (op. cit., Heft i, p. 94); and, in both of these, "hooks are to be seen near the upper or cephalic end, perfectly similar to those figured in plate ix"; but, writing at a later date (op. cit., Heft vii, p. 55), he says he is not certain what kind of mantle or pen might have belonged to this species. Münster's type and only specimen of *A. Férussacii* exhibits an elongated mantle, rather large head, and short arms (each provided with two rows of hooklets), but Münster says he had no knowledge of the pen of this species. The specimen described below is referred to Münster's *A. speciosa* on account of the shape of the hooklets of its arms.

In his "Handbuch der Palaeontologie" (vol. ii, p. 520, fig. 714), Prof. Dr. K. A. v. Zittel figures an example of *A. speciosa* from the Lithographic Stone of Eichstädt, Bavaria, in which the arms, each

[1] Münster submitted the specimens to R. Wagner, and the letter in which the latter suggested the generic name *Acanthoteuthis* is published by Münster in his "Beiträge zur Petrefacten-kunde," Heft i, 1839, p. 94.

[2] "Beiträge zur Petrefacten-kunde," Heft v, 1842, p. 97; and ibid., Heft vii, 1846, p. 55 et seq.

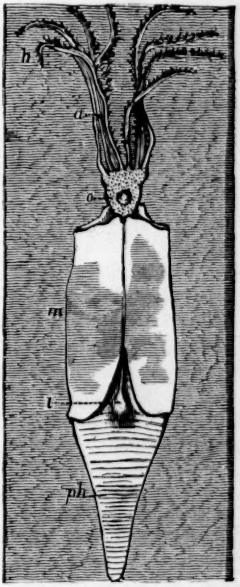
[3] "Die fossilen Ueberreste von nackten Dintenfischen aus dem Lithographischen Schiefer und dem Lias des süddeutschen Juragebirges": Abhandl. d. k. Akad. d. Wissensch. Berlin, math.-phys. Cl., vol. viii, p. 784.

bearing two rows of hooks, are attached to an elongated irregularly-shaped body; and at a later date, in his "Grundzüge der Palaeontologie" (p. 443), Professor Zittel also refers to this species the phragmocone and pro-ostracum which he had previously ("Handb. d. Palaeont.," pp. 510–1) assigned to a distinct genus (*Ostracoteuthis*). He states, moreover, that "in the Lithographic Stone of Eichstädt a slab has been lately found which displays the shell and the impression of the animal in association. In the body is an ink-bag; the head is surrounded by ten arms, each furnished with two rows of horny hooks."

Since remains of the animal in association with the arms are so seldom found, it seems desirable to place on record a specimen which has recently been acquired by the British Museum from the Lithographic Stone of Eichstädt, Bavaria (Plate I).

The specimen, which is exposed on the surface of a slab, has a total length (including the arms) of about 380 mm. The arms are well shown; the impression of the body is more obscure, but can be fairly well made out in a very oblique light. Seven or eight arms (*a*) can be counted, but they are so disposed upon each other, and some of them so obscured by dendritic markings, that their exact number cannot be ascertained. The longest is fully 120 mm. in length. The hooklets (*g*) are arranged in two rows on each arm; they are small near the head, gradually increase in size along two-thirds of the length of the arm, and become smaller towards the extremity. The hooklets themselves are not preserved, only their impressions. The largest (*h*) is 7·5 mm. long, and the length of its oblique base 2·75 mm. The impressions show that the central portion of each hooklet is depressed so as to leave a ridge on either side, exactly as Münster described in *A. speciosa*. At the base of the arms there is a depression filled with calcite (*b*), indicating the position of the head. Immediately behind the arms there is an oval impression, the smaller end of which is directed backwards; its outline is much more convex, and also more distinct, on the right than on the left side of the specimen; the greater part of the right side of this impression is covered with a thin whitish film, probably the remains of the mantle. Two subparallel obscure grooves extend from the mass of calcite (*b*) across this impression, and pass posteriorly into a triangular depression filled with calcite (*c*); near its anterior end the groove on the right gives off a branch which curves backward and outward, and appears to meet a groove which is continuous with the right side of the triangular depression. From the posterior portion of the oval impression already described the outline of the body gradually expands into a leaf-shaped form, the greater part of which is also covered with a thin whitish film, probably the remains of the mantle. This leaf-shaped portion appears to be formed of two lappets (*e* and *f*), each of which terminates posteriorly in a somewhat indistinct submucronate point, and bears several very shallow grooves, some of which are parallel to its margin. Posterior to the triangular mass of calcite (*c*), there is a well-marked shallow depression with subparallel sides that is

traversed by several obscure longitudinal grooves. This possibly represents a portion of the mantle-cavity, for into its posterior part opens the duct of the ink-bag (*d*). The latter is not filled with ink; the posterior portion, i.e. the portion below the dotted line *d*, is hollow and was evidently the "reservoir," while the anterior portion, i.e. the part above the dotted line *d*, has a sponge-like structure and is doubtless the remains of the "pigment-gland." There are no indications of a phragmocone or of an internal shell of any description.



Belemnoteuthis antiqua, Pearce.

a, arms with their hooklets; *o*, remains of the head, with eye; *m*, mantle, with indications of lateral fins; *i*, ink-bag, covered by the pallial integument; *ph*, remains of the phragmocone and of the rudimentary guard.

Now the arms of *Belemnoteuthis*[1] from the Oxford Clay of Christian Malford, Wilts, are furnished with hooks similar to those of *Acanthoteuthis*; and from an examination of one[2] of Münster's specimens, in which small hooklets were associated with a phragmocone,

[1] J. Channing Pearce, in Proc. Geol. Soc., vol. iii, 1841–2, p. 593. See also Professor Owen, "A Description of certain Belemnites found, with a great portion of their soft parts, in the Oxford Clay, at Christian Malford, in Wiltshire": Phil. Trans. 1844, pp. 65–85. J. C. Pearce, "On the Fossil Cephalopoda constituting the genus *Belemnoteuthis*, Pearce": London Geol. Journ. 1846, p. 75. W. Cunnington, "On the Fossil Cephalopoda constituting the genus *Belemnoteuthis*, Pearce": London Geol. Journ., May, 1847, p. 95. G. A. Mantell, "Observations on some Belemnites and other Fossil Remains of Cephalopoda in the Oxford Clay near Trowbridge, Wiltshire": Phil. Trans. 1848, pp. 171–181. G. A. Mantell, "Supplementary Observations, etc.": Phil. Trans. 1850, pp. 393–8.

[2] Described in Neues Jahrbuch, 1836, p. 583.

A. Wagner[1] considered that *Acanthoteuthis speciosa* was referable to *Belemnoteuthis*. Professor Huxley[2] concluded his excellent summary of the literature bearing upon this subject as follows:—

"Upon the whole it becomes plain that the *Acanthoteuthes* of Münster, so far as they are known only by hooks and impressions of soft parts, may have been either *Belemnites*, or *Belemnoteuthes*, or *Plesioteuthes*, or may have belonged to the genus *Celæno*; and that, with the evidence before us, it is impossible to say whether *Acanthoteuthis speciosa* and *Férussacii* belong to *Belemnites* or to *Belemnoteuthis*. . . . . Though it is quite possible that either *A. speciosa* or *A. Férussacii* may be really a *Belemnoteuthis*, we have no certain knowledge of the fact" (p. 21).

In his "Handbuch der Palaeontologie" (vol. ii, p. 520) Professor Zittel referred *Acanthoteuthis* to the Octopoda; but in his "Grundzüge der Palaeontologie" (p. 443) he places the genus in the Belemnoteuthidæ and unites with it the phragmocone and pro-ostracum which in his "Handbuch" (vol. ii, pp. 510, 511) he had designated *Ostracoteuthis*.

The specimen described above exhibits no trace of a phragmocone or of a pro-ostracum; but the general form of the body closely resembles—excluding the phragmocone—that of an example of *Belemnoteuthis antiqua* (from the Oxford Clay of Christian Malford) in the British Museum Collection, the lappets at the posterior portion of the body being comparable with the lateral expansions so well shown in that specimen. But in *Belemnoteuthis* the ink-bag is very near the ends of these lateral expansions, whereas in the example of *Acanthoteuthis* described above, it is farther removed from their posterior extremities and is relatively smaller. Still we think the genus *Acanthoteuthis* is properly referred to the Belemnoteuthidæ.

EXPLANATION OF PLATE I.

Figure of *Acanthoteuthis speciosa*, Münster, from the Lithographic Stone of Eichstädt, Bavaria.—*a*, arms. *b*, mass of calcite, probably indicating position of head. *c*, triangular mass of calcite. *d*, ink-bag. *e*, *f*, leaf-shaped lappets. *g*, hooklets of arms. *h*, hooklet enlarged twice natural size.—The figure is a little less than one-half of the natural size.

II.—Notes on the Geology and Palæontology of Argentina.

By Florentino Ameghino.[3]

UNTIL a few years ago it was believed that the Territory of Patagonia was of an extremely simple and uniform geological structure; it was supposed that from the Colorado to the Straits of Magellan, and from the Atlantic to the base of the foot-hills of the

[1] Op. cit., p. 820.

[2] "On the Structure of the Belemnitidæ; with a description of a more complete Specimen of *Belemnites* than any hitherto known, and an account of a New Genus of Belemnitidæ, *Xiphoteuthis*": Mem. Geol. Surv. United Kingdom, Figures and Descriptions illustrative of British Organic Remains, Monograph ii, 1864.

[3] "Notas sobre Cuestiones de Geología y Paleontología Argentinas": Bol. Inst. Geografico Argentino. vol. xvii, 1896, pp. 87-108. Translated, with Supplementary Observations, by Arthur Smith Woodward.

Andes, it was constituted exclusively by the marine Patagonian Formation, on the age of which the most varied opinions were expressed, although all agreed in referring it to the Tertiary series. This uniformity was interrupted only at intervals by great sheets of basalt which appeared sometimes at the surface, sometimes below the boulder-deposit.

The results of the travels of my brother, Carlos Ameghino, who since the year 1887 has dedicated himself exclusively to the geological and palæontological exploration of the regions of Patagonia, have completely changed this view. These explorations, which have revealed the former existence in the southern extremity of South America of various truly remarkable extinct faunas (as the most illustrious palæontologists of the present day term them), have also demonstrated to us that the Territory of Patagonia is not of so uniform a geological constitution as was said, since it comprises formations of different periods, marine and terrestrial or fluviatile, the latter predominating over the former.

Hitherto he has only published a review of his two first voyages,[1] but he is preparing a detailed description of all his explorations, and although on my part I have given some short notices of his discoveries on different occasions, it has appeared to me useful to attempt a sketch here of the principal geological results obtained.

Little can be said concerning the most ancient sedimentary formations, since these are only visible at certain points where they have been raised by the eruption of large masses of igneous rocks, principally porphyries, which have placed them within range of discovery; this happens in the central part of the Territory of Chubut, and also in the region of the Deseado and various other places.

Supposed Jurassic Strata.

The most ancient sedimentary deposits, which rest immediately upon these eruptive rocks, appear in the upper course of the River Chubut (the tributary Teca) and in the River Genua; they are shales and red sandstones whose age it is difficult to fix, but it is almost certain that they are not more modern than the Jurassic. As they have not hitherto yielded fossils, nothing more precise can be said.

Cretaceous Strata.

Upon these deposits comes a gigantic formation termed by C. Ameghino the variegated sandstones (*areniscas abigarradas*). "They are composed chiefly of enormous banks of sand, generally of fine grain, with beds of clay and intercalated conglomerates, assuming all the colours and shades imaginable (bright red, purple, ruddy, yellow, green, bronze, etc.)." It occupies the greater part of the course of the River Chubut, a part of the region of the Senguel, and in certain places extends even as far as the Atlantic coast. Its thickness is to be reckoned in hundreds of metres, with

[1] C. Ameghino, "Exploraciones geologicas en la Patagonia": Bol. Inst. Geograf. Argent., vol. xi, 1890, pp. 1–46.

its almost horizontal beds slightly inclined to the east and not exhibiting the least unconformity between each other.

Although no fossil remains are yet known from this formation, it is almost certain that it ought to be referred to the Lower or Middle Cretaceous, since the deposits which rest immediately upon it belong to the Upper Cretaceous. In fact, at various points, e.g., on the Senguel, the Deseado, etc., above these variegated sandstones and in concordant stratification, there comes another formation of red sandstones, a little more friable but also of great thickness and containing a considerable quantity of bones of gigantic Dinosaurs. These deposits constitute a vast formation which extends from one end of Patagonia to the other, since it has been observed from the River Negro and the Neuquen to the north, as far as San Julian and Lake Argentina to the south, always with the same characters, everywhere containing remains of Dinosaurs and a remarkable quantity of petrified wood; large complete trunks are continually observed still standing in their natural position.

That this formation is Secondary, is clearly indicated by the Dinosaurs; on the other hand, as its upper beds pass insensibly into another formation, which contains numerous remains of mammals, it cannot be doubted that the sandstones with Dinosaurs belong to the Upper Cretaceous. Mr. Lydekker has given a description of the Dinosaurian remains from this formation preserved in the Museum of La Plata.[1] The species which has left most remains belongs, according to him, to the genus from the Cretaceous of India which he had previously described under the name of *Titanosaurus*, and he terms the Argentine species *Titanosaurus australis*. This conclusion would be indisputably of great importance, but I have my reasons for doubting the generic identity. The other remains are described under the names of *Titanosaurus nanus*, Lyd.; *Argyrosaurus superbus*, Lyd., one of the most gigantic colossal animals which have trodden the earth;[2] and *Microcœlus Patagonicus*, Lyd.

The author observes that until his memoir no representative of this group from the Argentine Republic had been described, but that C. Burmeister had published some preliminary notices of them. These notices, published in the year 1893,[3] are confined to the indication of having met with remains which he supposes to be Dinosaurian—remains whose occurrence in Patagonia had already been reported by Carlos Ameghino.[4] There is also a lack of

[1] R. Lydekker, "The Dinosaurs of Patagonia": Anal. Mus. La Plata—Pal. Argent., vol. ii, 1894, pt. 1.

[2] The gigantic fore-limb of this animal, which serves as the type of the genus and species, was discovered by Carlos Ameghino, together with the almost complete skeleton in position, at the angle which the River Chico makes with Lake Musters (see F. Ameghino, "Contrib. conoc. mamif. fos. Repub. Argentina," 1889, p. 879; and C. Ameghino, Bol. Inst. Geogr. Argent., vol. xi, 1890, p. 42). Unfortunately, the incompetent persons employed by the Director of the Museum of La Plata for the exhumation of this skeleton only succeeded in extricating one of the limbs, destroying the remainder. The traveller who has occasion to cross this district still descries from a great distance the accumulation of bones destroyed by their vandal expedition.

[3] Revista del Museo de La Plata, vol. iv, 1893, pp. 245–6.

[4] Carlos Ameghino, Bol. Inst. Geogr. Argent., vol. xi, 1890, pp. 42, 44.

fairness on the part of the author in not having mentioned that the first notices of the remains of these animals and the determination that they belonged to Dinosaurs, were made by me in various publications, some prior to the foundation of the Museum at La Plata;[1] and the greater part of the remains of *Titanosaurus* figured by the author formed part of my old collection,[2] I not having described them for reasons which need not be mentioned.

However that may be, the presence of the Dinosauria in the formation of red sandstones is of the highest importance, not only from the palæontological point of view, but also because they form a fixed point of departure for the determination of the geological age of the strata resting upon them. These animals are essentially characteristic of Mesozoic times, and with their disappearance in Europe and North America coincides the appearance of the placental mammals, especially of the ungulates. In Patagonia the beds with remains of Dinosaurs pass insensibly into other beds with numerous remains of mammals, particularly of ungulates, which circumstance proves that the red sandstones ought to be referred to the Upper Cretaceous.

The *Pyrotherium* Formation.

This brings us to the somewhat more modern deposits, which I have designated with the name of *Pyrotherium Formation* ("Couches à *Pyrotherium*," in Bol. Inst. Geogr. Argent., vol. xv, pp. 603–8), specially intending not to prejudge their geological age; but, according to my first impression, which has not hitherto been in any way modified, they ought to be assigned to the most modern series of the Cretaceous formation.

The mammal-fauna of the *Pyrotherium* beds is one of the greatest interest, and its discovery is destined to elucidate many biological mysteries concerning the origin of the different groups of the class Mammalia.

In 1895 I gave a description of the principal types at that time known,[3] but the later explorations of Carlos Ameghino have

[1] F. Ameghino, Bol. Acad. Nac. de Cienc., vol. viii, 1885, p. 150; and "Contrib. conoc. mamif. fos. Repub. Argent.," 1889, pp. 16, 899, 959. The first remains of Dinosaurs met with in Patagonia, consisting of a complete caudal vertebra and a large rib with the articular head complete, were found in the Neuquen in the year 1882 by Captain Buratowich, and presented by him to the then President of the Republic (General Julio A. Roca), who in his turn presented them to me, and I immediately determined them as belonging to a gigantic Dinosaurian (see *La Nacion*, March 23, 1883). This was the first notice of the former existence of these singular extinct reptiles on the soil of the Argentine Republic.

[2] These remains, from Fort Roca, were presented to me by their discoverer, Señor Don Jorge Rohde, then Captain (now Colonel) of the Military Engineers.

[3] F. Ameghino, "Première Contribution à la Connaissance de la Faune Mammalogique des Couches à *Pyrotherium*": Bol. Inst. Geogr. Argent., vol. xv, 1895, pp. 603 61. In reference to this work, Mr. S. P. Palmer, of the U. S. Department of Agriculture, who is editing a "Nomenclator" of the known genera of mammalia, writes to me that the names *Clorinda* and *Eurygenium*, with which I have designated two extinct mammals from this formation, have been previously employed for other animals. The observation is correct, and it is all the more strange since I had not noticed that the two generic names are recorded in Scudder's "Nomenclator Zoologicus," which I always have at hand. I am thus compelled to change those names, replacing that of *Clorinda* by *Plagiarthrus*, and that of *Eurygenium* by *Eurygeniops*.

already tripled that number. These new discoveries, which enrich palæontology so much, will be described in detail in special works; meanwhile it is of interest here to take a rapid glance at the principal new types.

The armoured edentates are abundant, but it is evident that the representatives with a ringed carapace, which form the groups of Dasypoda and Peltateloidea, predominate over those with a more or less immovable carapace of the type of the Glyptodontia. Moreover, the latter are only represented by species whose carapace lacks the external sculpture, as in the more modern genera *Neuryurus*, *Pseudoeuryurus*, etc., which, because of this peculiarity, Lydekker (in his recent work on the fossil edentates of Argentina[1]) considers to have been founded on remains of young individuals in which the sculpture has not yet been developed. According to this curious interpretation, the Glyptodonts of the age of *Pyrotherium*, more fortunate than ourselves, remained always young, since the sculpture on the surface of the carapace was never developed. These ancient armadillos, for which I have proposed the name of *Palæopeltis*, differ also from the most recent forms in exhibiting the plates in well-defined transverse rows and to a great extent movable, thus constituting a complete transition between the most modern Glyptodonts with immovable carapace and the armadillos with ringed carapace.

The unarmoured edentates are also numerous and of types resembling those of the Santa Cruz Formation, but generally of much more considerable size. Nevertheless, some forms show very primitive characters, having the molars provided with a well-developed layer of enamel.

With these edentates there are carnivorous animals of a size approximating to that of the largest bears of the present day, but similar to those of the Santa Cruz Formation, and thus belonging also to the group of Sparassodonta, which is distinguished by a mixture of the characters of the polyprotodont Marsupials, the Creodonta, and the placental Carnivora.

The Plagiaulacoidea are also represented by various forms, of which the multituberculate molars exhibit a remarkable transition between the more modern types of the Santa Cruz Formation and those of the Mesozoic formations of Europe and North America.

The rodents are not numerous and appear to approach the Acaremyini of Santa Cruz, but they differ from these in exhibiting five lower molars in function on each side of the mandible, two premolars, and three true molars. Except in the Leporidæ, this is the greatest number of molars met with in mammals of this order: that we are dealing with a primitive character is evident, and this confirms my opinion that the hystricomorphous rodents originated in South America, and not in the Old World as most authors suppose.

[1] R. Lydekker, "Extinct Edentates of Argentina": Anal. Mus. La Plata—Pal. Argent., vol. iii, 1895, pt. 2.

Notwithstanding the discovery of these animals of small size, the ungulates always maintain the same numerical preponderance, the genera and species being those which I indicated in my preliminary memoir on this fauna, though to the known types there are now added other new ones still more interesting. There has appeared, for example, a whole series of ungulates with mammillated teeth, the classification of which is for the moment very doubtful, but which, at least in the dentition, appear to resemble the Phenacodontidæ of North America; for the present the only notable difference worthy of remark is that the Argentine forms exhibit the dentition in a continuous series.

As I have already suspected previously and pointed out in my work on this fauna, the Proterotheriidæ, such as are known from Santa Cruz and from the deposits of the Parana, do not exist in this formation. The forms which replace them have a complete dentition, presenting also, at least in the shape of the molars, a certain resemblance to the Ancylopoda, those ancient ungulates with hook-shaped toes and the ungual phalanges cleft as in some edentates. Moreover, it happens that the animals which represent the predecessors of the Macraucheniidæ in this formation also exhibit affinities with the Ancylopoda. Among the Typotheriidæ the same resemblance is observed, while some forms apparently of this group, from the structure of the skull and the aspect of the dentition, seem to be the direct forerunners of the modern Hyracoidea of Africa and Asia, one of the few types of existing ungulates which has hitherto appeared completely isolated and without predecessors.

In the representatives of the order of Toxodonts, which are very numerous, these same transitional characters are still more surprising; for while, on the one hand, they pass into the Ancylopoda, on the other they approach the typical Perissodactyla (Stereopterna): this transition is very clearly seen both in the conformation of the dentition and cranium and in the construction of the foot. The transition between the Ancylopoda and the Astrapotheria, at least in the dentition, is equally complete.

These various groups show among themselves less differences than in the Santa Cruz Formation, while by the characters which they exhibit in common in the *Pyrotherium* Formation, they seem to converge towards the Ancylopoda as if this were the original trunk of the ungulates. The only group which appears as yet to constitute an exception is that of the Pyrotheria and its descendants the Proboscidea.

However, perhaps the most important discovery is the finding in these same deposits of remains of monkeys perfectly characterized. We are not, indeed, dealing with types as specialized as the Homunculidæ of the Santa Cruz Formation, but with lower forms which, although they belong indisputably to the group of monkeys, pass into a whole series of animals which have been arranged among the ungulata.

In an article on the fossil monkeys of the Eocene of the Argentine

Republic[1] published in 1891, I arrived at the conclusion that there must have existed a genetic connection between the Typotheriidæ and the monkeys, and that the original stem of the Primates must be sought for in the deposits of the latest periods of the Cretaceous epoch. The discoveries recently made in the *Pyrotherium* Formation prove that that is actually the case. The Primates of this period completely connect the Homunculidæ with the Protypotheriidæ, and at present it seems as if the Homunculidæ, Protypotheriidæ, and Lemuridæ were three divergent branches of one and the same stem.

The Typotheriidæ, finally raised by Zittel to the rank of a sub-order (Typotheria), constitute one of the most singular groups of mammals; regarded successively first as ungulates, then as unguiculates, most authors have united them with the Toxodonts, while others have associated them with the rodents and some with the edentates. These curious animals, of which the better-known genera are *Typotherium*, *Pachyrucos*, *Protypotherium*, *Hegetotherium*, *Icochilas*, *Trachytheras*, etc., become then a branch diverging from the same stem whence the monkeys arise, a branch which becomes isolated by evolution since the Cretaceous epoch, and the last representatives of which (*Typotherium*) approximate to the Toxodonts through parallel evolution, in the same way that the Proterotheriidæ resemble the horses in the structure of their feet without any very close relationship existing between these two groups.[2]

What is the precise geological epoch to which date back the deposits containing the remains of this singular fauna? In my opinion, as I have indicated above, they are decidedly Cretaceous.

I rely on the fact that these beds with remains of *Pyrotherium* everywhere accompany the red sandstones with remains of Dinosaurs, so that it has not hitherto been possible to separate them in an absolute manner. These sandstones in certain places exhibit nothing but bones of Dinosaurs; in others they show only remains of mammals and smaller reptiles of types not yet determined;[3] while at other points all these remains are shown mixed together, at least to all appearance, always accompanied by a great quantity of silicified wood. In all parts where it has been possible to examine sections, the Cretaceous beds display a concordant stratification from the bottom to the top, without interruption of any kind, so that it is indubitable that the strata with *Pyrotherium* have been continued without interruption into those with Dinosauria. Still more; in some places in the territory of Chubut the variegated sandstones (*areniscas abigarradas*) of the interior extend even as far as the coast of the Atlantic, and are covered in concordant stratification by the same strata with *Pyrotherium*, which are submerged beneath the waters of

[1] F. Ameghino, "Los Monos fosiles de la Republica Argentina": Revista Argent. Hist. Nat., vol. i, 1891, pp. 383–97, figs. 85–97.

[2] So much interest has been aroused in the fossils of the Patagonian region that the North American Government has despatched an expedition with the object of collecting fossils for the museums of the United States. This expedition is in charge of Messrs. J. B. Hatcher and O. A. Peterson, who are already in Patagonia.

[3] See supplementary note by the translator, p. 21.]

the ocean, indicating that at that epoch the continent extended much more to the east than at any of the later periods.

It is useless to attempt to minimize the clear significance of these facts, saying that the Dinosauria may have lived in Patagonia until a more recent epoch than in other regions of the globe, because the stratigraphical data appear conclusive, and on the other hand the marine fauna leads to absolutely identical results, as is demonstrated by some brief considerations on the Patagonian Formation, which some authors, who are not acquainted with it, attempt to refer to the Miocene, while all who have studied its fauna are agreed in regarding it as Eocene.[1] If the terrestrial formations of Patagonia pass insensibly from the Cretaceous to the Tertiary, we shall see that exactly the same happens with the marine formations of the same region.

The Patagonian Formation.

In the interior of the Territory of Chubut and in northern Patagonia, in the upper course of the River Negro and of the Neuquen, the *Pyrotherium* Formation is found covered by more modern deposits of terrestrial or fresh-water origin, whose fauna is still unknown to us, except some or other remains referable to the Ancylopoda. In the region of the Atlantic coast, on the contrary, the beds with *Pyrotherium* are found below the marine Patagonian Formation. As I have had occasion to point out in another work,[2] this is a fact definitely ascertained and beyond all dispute, since the direct superposition of these two formations has been determined by Carlos Ameghino at more than fifty distinct points, very far from one another.

On the coast the greatest development of the Patagonian Formation is met with to the south of the River Deseado as far as the mouth of the River Santa Cruz, but towards the interior it disappears beneath the thick strata of the Santa Cruz Formation; to the south of the River Santa Cruz it diminishes gradually in thickness, and disappears beneath the sea before reaching the River Coyle, being replaced in the cliffs by the Santa Cruz Formation. The point of its greatest development is found in San Julian, where it attains a thickness of approximately 300 metres.

A most important fact, which must not be forgotten for a moment, is that the true Patagonian Formation of the coast of Patagonia is not to be confounded with the marine formations of the neighbourhood of the Parana. This identification is a grave error which has given rise to many others, since, as I have shown in another work,[3] the marine deposits in this latter locality are indisputably more modern than the deposits with *Ostrea Patagonica* of the coast of Patagonia.

[1] See supplementary note by the translator, p. 22.]

[2] F. Ameghino, "Première Contrib. Connais. Faune Mammal. Couches à *Pyrotherium*": Bol. Inst. Geogr. Argent., vol. xv, p. 605.

[3] F. Ameghino, "Enumération Synoptique des Espèces de Mammifères Fossiles des Formations Eocènes de Patagonie," p. 5 (Buenos Aires, 1894).

The true Patagonian Formation is undoubtedly Eocene, while its basal or inferior part belongs to the Cretaceous. All the malacologists (D'Orbigny, Sowerby, Philippi, Hupé, Remond de Corbineau, Steinmann) who have studied the shells of this formation, have assigned it to the Eocene, and some to the Upper Cretaceous. All have recognized that the molluscs, even those of the upper beds, belong entirely to extinct species. The fact is, that the Patagonian Formation begins with the Upper Cretaceous, but acquires its great development during the Eocene. The fossiliferous deposits of Quiriquina were at first regarded as Tertiary, and were only assigned to the Cretaceous after there had been discovered in them remains of *Plesiosaurus* (*Cimoliosaurus*) *Chilensis*, of *Ammonites*, and some other Secondary genera.

The late Cretaceous formation of the coast of Chili exhibits absolutely the same aspect and the same lithological characters as the Patagonian Formation. The facies of the fauna is equally the same, since the Cretaceous fauna of Quiriquina only differs from the fauna of the Patagonian Formation by the presence of eight genera (*Ammonites, Hamites, Baculites, Pugnellus, Cinulia, Pholadomya, Monopleura, Trigonia*), which are not met with in this latter; while 85 per cent., more or less, of the genera of the Cretaceous formation are also found in the Eocene Patagonian Formation. Moreover, according to Philippi, the best authority on the subject, 20 per cent. of the species of shells of the Cretaceous formation of Algarrobo are likewise species of the Patagonian Formation, and it will be recognized that in Patagonia the marine Cretaceous and Eocene formations pass from one to the other in a gradual and insensible manner.

At different points on the coast of Chili, the Cretaceous beds are covered by a stratum of lignite, which appears to be the same as that worked at Punta Arenas, and which on this side of the Cordillera extends to the north, below the Patagonian Formation, appearing successively at the source of the Coyle, in the neighbourhood of Lake Argentina, in the bay of San Julian, in the River Chico, and at other points.

In the vicinity of Lake Viedma, the lower beds of the Patagonian Formation contain remains of Chondropterygian fishes of Cretaceous species or genera, as *Lamna* (*Otodus*) *Argentina*, Amegh., very close to *Lamna* (*Otodus*) *divaricatus*, Leidy, from the Cretaceous of North America; teeth absolutely similar to those of *Lamna subulata*, Agass., and *Oxyrhina Mantelli*, Agass., from the Cretaceous of Europe,[1] teeth of the Cretaceous genus *Sphenodus*, etc. These remains are found mingled with those of a genus of reptiles of the group of the Plesiosauria (*Polyptychodon Patagonicus*, Amegh.), and another of the family Mosasauridæ (*Liodon Argentinus*, Amegh.[2]), both characteristic of the Cretaceous formations.

Being, then, an indisputable fact that the beds with *Pyrotherium* are anterior to the base of the Patagonian Formation, it is absolutely

[1] F. Ameghino, "Sobre la Presencia de Vertebrados de Aspecto Mesozoico, etc.": Revista Jardin Zool. Buenos Aires, vol. i, 1893, p. 85.

[2] F. Ameghino, ibid., pp. 79-83.

impossible to attribute them to an age more recent than the Upper Cretaceous.

From my point of view there has hitherto been advanced only a single sufficiently serious argument against the antiquity of the Patagonian Formation, and it consists in the presence of numerous remains of Cetacea, which (if we except the Zeuglodonts, which are undoubtedly very different animals) only appear in Europe and North America during the Miocene period. But we are dealing with a negative proof, the worth of which is only apparent, since it does not take into account the fact that these animals appear there completely developed, without their predecessors being known, and certainly they did not fall from the sky, but went there as emigrants from other regions. The Cetacea, indeed, are a group of mammals which arose in South America and emigrated to the northern hemisphere, at a comparatively recent geological period, when they had already acquired all their principal distinctive characters.

It is enough to glance at the remarkable memoir of Lydekker on the skulls of fossil Cetacea from Chubut[1]—*Physodon Patagonicus*, Lyd., *Diaphorocetus Poucheti* (Mor.), Amegh.,[2] *Prosqualodon australis*, Lyd., *Argyrocetus Patagonicus*, and *Diochoticus Benedeni* (Mor.), Amegh.[3]—which come from Puerto Madryn, from the most modern beds of the Patagonian Formation,[4] to perceive that we are dealing with more primitive and less specialized types than those obtained from the Miocene deposits of Europe and North America; this is especially very evident in the genera *Argyrodelphis* and *Prosqualodon*.

[1] R. Lydekker, "Cetacean Skulls from Patagonia": Anal. Mus. La Plata—Pal. Argent., vol. ii, 1894, pt. 2. As I have observed on another occasion, this volume, although it bears the date 1893, appeared more recently, in the month of April, 1894.

[2] In his work Lydekker designates this Cetacean with two distinct generic names; in the heading of the description he employs the name of *Hypocetus*, which is also met with below the figure on the corresponding plate, while at the end of the description he uses the name of *Paracetus* in substitution for that of *Mesocetus*, which Moreno had given to replace this latter, preoccupied for another genus of the same group. For my part, I had already replaced the name of *Mesocetus* by that of *Diaphorocetus* (F. Ameghino, Bol. Acad. Nac. Cienc., vol. xiii, p. 437), placing the genus, though only in a provisional way, among the Pontoplanodidæ, since my principal object was to give a complete list of all the Tertiary mammals of Patagonia. I ought to observe that in reality the genus in question exhibits no relationship with the latter group, but with that of the Physeteridæ, as observed by Lydekker, who, notwithstanding this, places it with *Physodon* in a new family, which he terms Physodontidæ. In accordance with the opinions expressed by Cope, it does not appear to me that the presence of teeth in the upper jaw is a character sufficient to justify the creation of a new family, since they are also found, though in less number, in representatives of some species of the allied existing genera (E. D. Cope, "Fourth Contribution to the Marine Fauna of the Miocene Period of the United States": Proc. Amer. Phil. Soc., vol. xxxiv, 1895, p. 135).

[3] Lydekker proposes for this genus the name of *Argyrodelphis* to replace that of *Notocetus*, under which Moreno had described it, because this latter was already employed by me for another Cetacean. For the same reason I had proposed that of *Diochoticus*, placing the genus among the Platanistidæ, the same arrangement as given by Lydekker (F. Ameghino, Bol. Acad. Nac. Cienc., vol. xiii, p. 438).

[4] It appears that neither the exact locality nor the precise geological horizon is known whence was obtained the skull described by Lydekker in the same work under the name of *Cetotherium Moreni*.

These primitive characters are recognized by Lydekker himself, who directs attention to them in a very special manner, and thus I need not enter into details.

The Santa Cruz Formation.

Above the Patagonian horizon there comes another very distinct formation, consisting of a series of marine and terrestrial deposits, the latter predominating over the former, to the whole of which I have given the name of Santacruzian.[1] Observed first in the interior, where the Patagonian Formation does not appear, it was supposed originally to be much anterior to this, but the subsequent exploration of other regions in which both formations are exhibited superposed has demonstrated the contrary, namely, that the Santa Cruz Formation rests on the Patagonian Formation.[2] The circumstance that the Tertiary deposits of the Parana had been identified with the Patagonian Formation, and the fact that the mammal fauna of the Santa Cruz Formation is evidently of a more ancient aspect than that of the Parana, doubtless contributed to the commission of that error. Unfortunately, the authors who have identified the marine formations of the Parana with the Patagonian Formation have fallen into an error, since the latter is of much older date.

On the Atlantic coast, the Santa Cruz Formation appears to the south of the River Santa Cruz, gradually increasing in thickness in proportion as there is an attenuation of the Patagonian Formation, which finally disappears completely below the sea-level before reaching the River Coyle; between this point and the River Gallegos the maximum thickness of the formation is about 260 metres. The greater part, or the Santacruzian zone properly so-called, which is uppermost and approaches a maximum development of about 200 to 230 metres, is of terrestrial or fresh-water origin; this consists of a series of strata of clay and volcanic detritus, sometimes also with calcareous accumulations, containing almost everywhere numerous remains of extinct mammals, gigantic birds, and also, though in less quantity, remains of reptiles. The mammal fauna is one of the most remarkable claiming the attention of all naturalists occupied with the study of the vertebrata. It is not necessary, and this is obviously not the place, to enter into the details of the subject, for the fauna in question has been the subject of numerous publications, and much more will continually be published upon it.[3] It suffices

[1] F. Ameghino, "Contrib. Conoc. Mamif. Fos. Repub. Argent.," pp. 16, 17 (Buenos Aires, 1889).

[2] F. Ameghino, "Enum. Synopt. Mamm. Foss. Eoc. Patagonie," pp. 4, 5 (Buenos Aires, 1894).

[3] I cannot, however, omit to mention here a recent discovery which has not yet been published, and which is doubtless destined to rouse great interest in the zoological world. One of the most singular groups of mammals of the Santa Cruz Formation comprises a series of small animals with the dentition somewhat similar to that of the kangaroos of Australia, but still more so to that of the fossil Plagiaulacoidea of the Mesozoic formations of Europe and North America. Those animals, marsupial though not syndactylous like the kangaroos, which I have distributed into the four families of Abderitidæ, Decastidæ, Epanorthidæ, and Garzonidæ, were at this period extremely numerous in genera and species, and in

for me to record that, although this fauna exhibits a very small number of genera in common with that of the Tertiary formations of the Parana and none with the *Pyrotherium* fauna, it presents a much greater general resemblance to the latter, and this proves its great geological antiquity.[1]

The base of the Santa Cruz Formation consists of a series of marine deposits of an average thickness of 30 metres, to the whole of which I have given the name of the supra-Patagonian horizon (étage sur patagonien),[2] because it rests directly on the Patagonian Formation. That the deposits just mentioned are of a period distinct from that of the latter formation, I have no doubt; for instead of *Ostrea Patagonica* they contain *Ostrea Bourgeoisi*, which is characteristic of this horizon, and this difference seems to extend likewise to almost the whole of the molluscan fauna.

This horizon, indeed, is of great importance by reason of the quantity of fossil species which it has afforded during the latest explorations. According to the data which Carlos Ameghino has given to me on the collections made there, in addition to *Ostrea Bourgeoisi*, characteristic as I have said of these deposits, there is also a species of the genus *Crenatula* whose known representatives live only in the tropical regions of India and in the Red Sea. The extinct genus *Amatusia* is represented by a species twice as large as that from the Eocene of Chili described by Philippi. There are also species of the genus *Hyanira*, whose representatives are for the most part characteristic of the Cretaceous, and more than a hundred other species of shells, among which are some fresh-water and terrestrial forms. There is likewise a great abundance of fossil crustacea, among which predominates the large *Cancer Patagonicus*, Phil., which itself forms banks of a considerable extent in that formation.

I have placed all these materials in the hands of Dr. H. von Jhering, who will give us the results of his studies. The foregoing does not conflict with what I have been able to advance, namely, that in my opinion we are dealing with an Eocene fauna, for many of those shells collected to the south of the River Santa Cruz, and erroneously regarded as coming from the Patagonian Formation, have all been recognized as extinct species. This same horizon is

respect to individuals they must have been more numerous than all the rodents of our pampa taken together. These animals have hitherto appeared to constitute an entirely extinct group without any direct affinities to any of the existing ones. Great, then, was my surprise when I received a letter from the distinguished zoologist of the British Museum, Mr. Oldfield Thomas, in which he informed me he had just received from Colombia (New Granada) an example of a still existing genus of the group of the Eocene Epanorthidæ of Patagonia, a genus which the gentleman in question will shortly describe. . . . Mr. J. B. Hatcher has lately informed me that the National Museum of Washington has just received an example of this same animal [=*Cænolestes obscurus*, O. Thomas, Proc. Zool. Soc. 1895, p. 870, pl. L].

[1] F. Ameghino, "Enum. Synopt.," etc., 1894, p. 7.

[2] Mr. J. B. Hatcher, who collected all the Cretaceous mammals described by Marsh, recently examined in my house the remains of Plagiaulacoidea from Patagonia, and told me that in his opinion they exhibit the greatest resemblance to those of the Upper Cretaceous (Laramie Formation) of the United States, described by Marsh.

shown well developed at Punta Arenas, covering in some parts the layers of lignite. The collection of fossil mollusca from this locality studied by Philippi, comes from this same horizon, with the single exception of *Ostrea Patagonica*, and all the species are considered by this distinguished malacologist to be extinct, and consequently as representing an Eocene fauna.

Now, it is also evident that that marine deposit (supra-Patagonian zone) and the Upper Santacruzian horizon form part of one and the same epoch, for in the lower portion of this terrestrial formation there are intercalated marine bands of the lower zone with *Ostrea Bourgeoisi* and other characteristic fossils of the same beds, resting upon deposits with remains of *Astrapotherium, Homalodontotherium, Proterotherium, Homunculus*, and all the other representatives of the marvellous mammal fauna of the Santa Cruz Formation.

We conclude from this, that the Santa Cruz Formation, and nearly the whole of the Patagonian Formation, represent in our country the complete series of the Eocene strata; while the lower and more ancient part of the Patagonian Formation, with the *Pyrotherium* beds which are found below it, corresponds with a portion of the Upper Cretaceous.

The Boulder Formation.

Above the earlier formations there come great sheets of basalt, and where this is wanting there is found the formation of Patagonian boulders, which, covering also the basalts, extend over the whole surface of Patagonia, both over the plateaux and over the slopes of the valleys; though the true boulder formation is that which covers the plateaux. The boulder deposits of the sides and the bottom of the valleys are the result of the falling down and transport at a comparatively modern period of the pebbles and boulders of the deposit which extends over the plateaux, and this is the only one with which I am concerned.

This deposit, perhaps the most gigantic boulder formation known on the surface of the earth, constitutes up till now a geological enigma. Of marine origin according to Darwin, who believed that nothing but the ocean could produce such a dispersion of boulders with the uniformity it presents, it has been regarded by almost all later authors as a product of the Glacial epoch. There is likewise difference of opinion as to the epoch to which it ought to be referred: Pampean according to some, it is of more recent date according to others, while there are not wanting those who believe that it immediately preceded the Pampean Formation.

In 1889,[1] relying on the data provided by C. Ameghino, which showed this formation to be in part derivative, with the materials appearing as if they had been rolled by water, and no trace of striæ or glacial polish or angular fragments which could have been transported by ice, I arrived at the conclusion that we were dealing with an accumulation produced by water without the intervention of glacial agencies. I recognized also that this accumulation might

[1] F. Ameghino, "Contrib. Conoc. Mamif. Fos. Repub. Argent.," p. 36.

have been commenced at a most ancient period, since between the boulders and the Santa Cruz Formation there are no intercalated sedimentary deposits of any kind.

The only difficulty which presented itself to me was, as to how the waters which descend from the Cordilleras to the Atlantic had been able to spread this boulder deposit in so uniform a manner, since the idea of marine action was excluded by the absence of marine remains in it. In any case, it will be a surprise to all, as it has been to me, to know that the Patagonian boulders are a marine formation, as Darwin originally said, but without any relation to glacial agencies and of a geological period much more remote than that to which all were more or less disposed to attribute it. On this subject Carlos Ameghino writes to me in a recent letter as follows:—

"Another of the facts also definitely ascertained on this journey, is the determination that the Tehuelche Formation, or that of the Patagonian boulders, is really a sediment of marine origin, as Darwin originally said, for now I have met with direct positive proofs such as the marine molluscs of that period are, with the only difference that, instead of being a formation of a comparatively recent period, as has hitherto been believed, it will have to be relegated to a much more remote period anterior to the Pampean Formation, because the species of *Ostrea* which it contains is of the same type and dimensions as the *Ostrea Bourgeoisi* of the Santa Cruz Formation. The reason why these deposits of fossil mollusca have hitherto escaped notice by all the explorers of Patagonia is, because they are completely isolated in the formation, and it is only in surveying an enormous superficial extent of the formation that there are chances of finding some of them by accident. These deposits occupy the summits of certain outliers of plateaux which have remained isolated and only rise a few metres above the general level of the surrounding plain, so that it appears as if at one time these fossils were distributed over all the remainder of the formation, but have only been preserved until to-day in these favoured spots and owing to causes which it has not hitherto been possible to explain to my satisfaction."

According to this, the boulders were deposited at the bottom of the sea, and over them there extended at other periods a vast formation of marine shells, of which there only remain diminished traces at certain definite spots. There was, then, after the epoch of the Santa Cruz Formation, a submergence of Patagonia, during which the sea penetrated as far as the foot of the Cordilleras; the definite emergence of those territories is posterior to the epoch of the boulder formation and of the banks of marine shells already mentioned superposed upon it. On the other hand, as the oysters of these banks are of large size and of a species similar to that characterizing the Santa Cruz Formation, there is every probability that the boulder formation is Miocene.

With this there certainly disappear the illusions of those who claim in some way to connect the boulder formation with a great

Glacial epoch; for although it is certain that there are yet some who believe not only in Miocene and Eocene, but also in Secondary Glacial periods, it is likewise certain that nobody pays attention to them.

The Transverse Valleys of Patagonia.

Having dispelled the ignorance as to the origin of the boulder formation, this leads us naturally to determine the age of the formation of the transverse valleys of Patagonia. It is evident that at the bottom of the ancient sea in which the boulders were deposited, these were scattered by the waters in a uniform manner over all the submerged territory. The same may be said of the sheets of basalt; those also must have extended in a comparatively uniform manner, without forming the steep cliffs which they exhibit to-day in the river valleys. Darwin, speaking of the scarps of the valley of the River Santa Cruz, said that the cliffs of basalt of the two opposite sides were recognizable immediately as at one time forming a continuous bed. The same may be said of the beds of boulders, which in many parts form the opposite cliffs of the Patagonian valleys; those beds were continuous across the valleys, but there are now no traces of them.

It is evident that if the valleys had existed before the great marine submergence referred to, they would have been completely filled with marine deposits, which, even supposing they had been swept away afterwards by the waters, would always have left numerous traces buried in the innumerable angles of the slopes; but as such deposits do not exist, the inevitable conclusion is, that the formation of the great transverse valleys of Patagonia was brought about by great dislocations and gigantic faults at a comparatively recent geological period, posterior to the boulder formation and at the last emergence of the land.

The Pampean Formation.

As deduced from these data, the Pampean Formation must be of more recent date than the boulders of the Tehuelche Formation, and thus it is in fact, though in Patagonia it exhibits small development. We must, however, except the interior of the southern extremity, in the region of the River Gallegos, where the deposits of loess, superposed on the boulders, attain in some places a thickness of 15 to 20 metres. With respect to the whole, since no fossils have hitherto been found here, it cannot be affirmed categorically that these deposits correspond with the Pampean Formation of the province of Buenos Aires, and they may be of a much more recent period.

This doubt does not exist with respect to the isolated deposits met with from the River Coyle to the north, even at the bottom of the valleys as happens at the mouth of the Santa Cruz, or in depressions of the Tertiary formation of the coast like the deposit at San Julian which yielded to Darwin the first remains of *Macrauchenia*. Others occupy ancient bays of the ocean, and then we meet with bones of land-mammals mixed with marine shells; on his recent journey

Carlos Ameghino found several deposits of the latter nature in the gulf of San Jorge. All these isolated patches or deposits of the Pampean horizon contain remains of extinct mammals of the same genera and species as those of the Pampean Formation of the province of Buenos Aires, which proves that they are of the same period.

This similarity in the fauna of regions so far apart from south to north as the provinces of Buenos Aires and Santa Fé, and of southern Patagonia, demonstrates with the strongest proof that those are mistaken who invoke the intervention of glacial agencies to explain the accumulation of the pampean clay. It is Dr. Steinmann[1] who in a few words has most exaggerated the importance of the glacial phenomena in this part of America, since he regards as of glacial origin the deposits which are met with immediately below the Pampean Formation as far as and beyond the same horizon of Monte Hermoso. He does not state his reason for this, a circumstance which does not prevent many people from accepting his opinion because of the authority which the writer referred to enjoys in respect to geological questions. But in the present case he has not studied the question, for he is not only unacquainted with the deposits of Monte Hermoso, but even with the same Pampean Formation of the province of Buenos Aires; consequently, in judging this question without proper data he has fallen into a lamentable error.

In all my works I have repeated, even to weariness, that absolutely no trace of glacial marks is met with in the Pampean Formation—that neither the fauna nor the flora indicate during any part of it the existence of a climate colder than the present one. The six or seven distinct mammal faunas which succeed one another from the deposit of Monte Hermoso to the top of the Pampean Formation, all indicate without exception a climate warmer and more uniform than the present one. The remains of reptiles, the fresh-water mollusca, and the numerous plant-remains obtained from the Pampean Formation, lead to the same conclusion. It only remains to examine from this point of view the fauna of marine mollusca of the same period. With the object of supplying that deficiency I made an extensive collection of marine mollusca from the Pampean Formation and sent it to Dr. H. von Jhering, specialist on the subject, and this distinguished naturalist writes to me that almost all the species still live on the shores of the south of Brazil.[2] With this, the discussion on this point must remain closed, for I consider it an impossibility to discover positive facts in opposition to what we know up to now

[1] G. Steinmann, "A Sketch of the Geology of South America": Amer. Nat. 1891, pp 855-60.

[2] H. von Jhering, "Conchas marinas da formaçao pampeana de La Plata": Revista do Museo Paulista, vol. i, 1895, pp. 223-31. This collection consists of nineteen species, all still existing on the Argentine coast except three, viz., *Purpura hæmastoma*, *Littorina flava*, and *Nassa polygona*: the first does not survive to the south of the Rio Grande del Sud, and the two last live in Santa Catalina, San Pablo, and more to the north. This indicates that the oceanic waters of that period had here a somewhat higher temperature than at present, which is in complete contradiction to the supposed glacial origin which some would attribute to the Pampean Formation.

concerning the Pampean Formation and the characters of the faunas and floras of the same period.

I can summarize everything relating to this question in this form:—Absolutely no trace of glacial action is met with either in the Pampean Formation or in the immediately pre-Pampean deposits; and no plant-species, no mammal, nor any species of mollusc, whether marine, terrestrial, or fresh-water, indicating a climate colder than that of the present day, is known from the base of the Monte Hermoso horizon to the most modern of the Pampean deposits.

Traces of ice-action in the form of ancient moraines, striated and polished rocks, erratic blocks, etc., are confined to the modern formations, post-Pampean, and always in the neighbourhood of the mountains, proving a greater development of the snow-regions owing to local physico-geographical causes of a very recent geological date.

III.—Observations on Señor Ameghino's "Notes on the Geology and Palæontology of Argentina."

By Arthur Smith Woodward, F.L.S., F.G.S.;
Of the British Museum (Natural History).

THE general conclusions of the brothers Ameghino in reference to the geology of Patagonia, as detailed in the foregoing valuable synopsis of results, may be still more briefly stated in the following manner:—

(1) The oldest sedimentary rocks in which fossils have been found are red sandstones, containing mineralized wood, Dinosaurian bones, and other smaller reptilian remains. "*Upper Cretaceous.*"

(2) The terrestrial or fresh-water *Pyrotherium* Beds succeed these and may be partly intercalated with them. They contain a singular mammalian fauna, notably primitive Ungulata. "*Upper Cretaceous.*"

(3) For some distance from the present coast, but not far in the interior, the *Pyrotherium* Beds are covered by the marine Patagonian formation. "*Upper Cretaceous and Eocene.*"

(4) The Santa Cruz Formation, marine at the base but terrestrial and fresh-water above (major portion), rests on the Patagonian Formation near the coast, on the older rocks in the interior, and contains a large mammalian fauna. "*Eocene.*"

(5) Next are local sheets of basalt, and a great "Boulder Formation" proved to be of marine origin by the occurrence of shells. "*Miocene.*"

(6) Uppermost lies the Pampean Formation, chiefly of marine origin, with six or seven successive mammalian faunas.

For the substantiation of these results we must still await the publication of the sections and the detailed field observations of Señor Carlos Ameghino, which are already promised. Assuming, however, that the stratigraphical succession here tabulated is correct, the problem of the geological age of the various strata still admits of discussion. It is well known that most authors disagree with Dr. Florentino Ameghino in assigning the two early mammalian faunas he distinguishes to so remote an antiquity as that which he claims for them. It is clear that, judged by the standards of the

northern hemisphere, the stage of evolution of these Patagonian faunas is much higher than any termed Eocene either in Europe or North America. I should therefore like to add a few new observations bearing upon the subject, which I was able to make during a visit to Argentina last autumn. Thanks to the kindness of the brothers Ameghino, I had the privilege of examining their unique collection, and Señor Florentino Ameghino gave to me (for the British Museum) the few fish-remains he possessed from the formations described. Dr. Moreno and Dr. Santiago Roth permitted me to study the collections in the Museum of La Plata, and Dr. Carlos Berg will shortly transmit to London for determination the series of fish-remains from Chubut and Parana now in the National Museum at Buenos Aires. Complete descriptions will appear later, but it is now opportune to make some preliminary remarks.

Firstly, as to the red sandstones with Dinosaurian remains, it may be added that Dr. Santiago Roth has recently brought back from the Territory of Neuquen a fine collection of the small undescribed reptilia to which Señor Ameghino refers (p. 10). One of these is a typical and apparently fully-evolved snake, which I had not time to study in detail. The others are small Crocodilia, of which I have prepared a description now being printed for the "Anales del Museo de La Plata." These crocodiles are particularly interesting because they are typically Mesosuchian, with the characteristic palate and amphicœlous vertebral centra. They seem to be most closely related to the small Purbeckian *Theriosuchus* and its allies, differing, among other features, in their more highly specialized dentition. Nearly all of them may be comprised in a new genus, which I have named *Notosuchus*. The skull is short and broad, with a much abbreviated rostrum, and the outer bones are externally rugose. The supratemporal fossæ are of moderate size, longer than broad; the orbits are relatively very large, directed both superiorly and laterally, and with a very slender internal post-orbital bar; a small antorbital vacuity occurs between the lachrymal and maxillary bones; and the nasals reach the single large narial opening, which is directed forwards. The mandible is slender, biting within the upper jaw, and its articular end is not curved upwards; there is a large vacuity in the side of each ramus, and the splenials enter the short pointed symphysis. The teeth are few in number and laterally compressed, some also feebly serrated; the series of the upper jaw is much differentiated, comprising two or three small "incisors" and one very large "canine" in each pre-maxilla, and seven teeth of more uniform size in each maxilla; while the series in the lower jaw comprises ten teeth on each side, these gradually increasing in size backwards and without any "canine." The limbs are typically crocodilian in every respect, and the fore-limb is not much smaller than the hind-limb. No dermal armour has been discovered with any specimen. The typical species, *Notosuchus terrestris*, has a skull about 0·15 m. in length. A second, closely-related genus, *Cynodontosuchus*, also exhibits the highly specialized dentition, but has large canines in the lower jaw,

crossing and working upon those of the upper jaw. The typical and only known species is *C. Rothi*, with a laterally compressed rostrum.

Hence, the new crocodilian fossils tend to increase rather than diminish previous estimates of the antiquity of the red sandstones of Neuquen.

As to the *Pyrotherium* Formation, it would be premature to discuss its wonderful mammalian fauna until the appearance of Señor Ameghino's memoir which he is now preparing. I would, however, urge that he should show quite clearly why *Pyrotherium* cannot be a close ally of the Australian *Diprotodon* and *Nototherium* when he describes the fine skeleton he now possesses. It certainly differs from the Proboscidea in some most fundamental characters.

The few fish-teeth believed to have been obtained from the *Pyrotherium* Formation are unfortunately all marked with a query (?), and were thus apparently not found in actual association with the mammalian remains. But it is interesting to notice that one Selachian tooth from Lake Argentina belongs to the genus *Synechodus*, hitherto found only in the Cretaceous of Europe and New Zealand; while a number of teeth of Lamnidæ from the same locality cannot be distinguished from the common *Lamna appendiculata* of the English Chalk, and others seem to agree equally well with *Odontaspis* (? *Scapanorhynchus*) *subulata*. It may also be added that two teeth found with these are of the form commonly named "*Saurocephalus*," and seem to be identical with those of the Cretaceous ganoid fish, *Protosphyræna*. The remains of fishes met with in certain deposits in regions where *Pyrotherium* occurs, are thus of a decidedly Cretaceous aspect.

The Patagonian Formation is obviously the means for solving the age of the Santa Cruz Beds, for it seems to intrude into the midst of their lower portion. Señor Ameghino, on the authority of the conchologists, assigns to it a great age, believing it to be Upper Cretaceous and Eocene; and in discussing the Miocene or almost Pliocene aspect of the Cetacea of this horizon, he argues that they must have originated in the region of Patagonia and migrated to the northern hemisphere at a later date. This may be so, but we can now add that the few Selachian teeth from the same deposit are also of a decidedly Pliocene or Miocene character. *Carcharodon megalodon*, or teeth extremely similar to those thus named, occur in the Patagonian Formation of Chubut; so also do large teeth of *Oxyrhina*, identical with those of the European Miocene and Pliocene *Oxyrhina hastalis*—much larger than any hitherto found in a Cretaceous or Eocene deposit. If their evidence be of any value, therefore, we must argue that not merely the Cetacea but also the fish-fauna of the Miocene of the northern hemisphere originated at an earlier date in the southern hemisphere. But in the present state of our geological knowledge it is still necessary to use the chronological terms in question in a homotaxial sense, without reference to any theories of migration or contemporaneity. The relative age of the mammaliferous Tertiary strata in the two hemispheres thus remains still too uncertain to base upon them any of the wide generalizations

which have already been attempted. The palæontologists of Argentina must be content for many years more to supplement the pioneer labours of Owen, Burmeister, and others, by the plodding detailed study of the unique osteological collections at their disposal; and none but those who have seen the material can appreciate thoroughly the overwhelming nature of this task.

IV.—On the Effect of the Great Japanese Earthquake of 1891 on the Seismic Activity of the Adjoining Districts.

By Charles Davison, Sc.D., F.G.S.;
King Edward's High School, Birmingham.

THE problem I have tried to solve in this paper is, whether the Mino-Owari, or great Japanese, earthquake of 1891 had any effect on the seismic activity of the surrounding regions. The effect we might anticipate would be either an increase or decrease in the frequency of shocks in those regions soon after the occurrence of the principal earthquake—a decrease if the stress were thereby diminished over the whole district, an increase if the stress were relieved in the central area and partially transferred to those adjoining it.

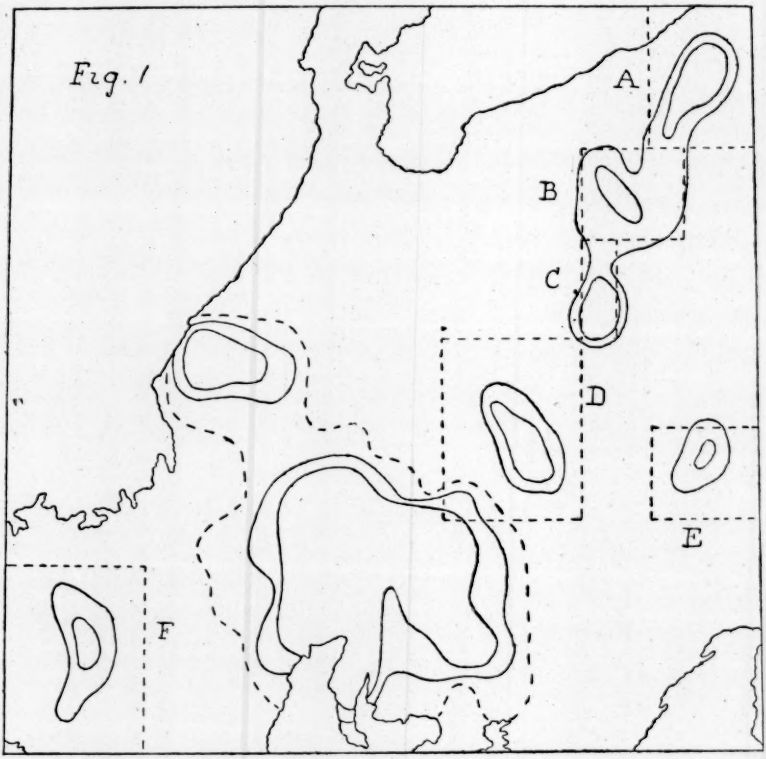
But, if such an increase, for example, were shown to take place, it would not necessarily be a direct consequence of the great earthquake. Both the central and the adjacent shocks, it is possible, might result from a general increase of stress over a wide extent of country, and the augmented frequency of the latter could not with justice be regarded as an undoubted effect of the former, for they might both be effects of the same cause. But, that the connection in the present case is one of real dependence, is very probable for the following reasons:—(1) An increase of stress cannot determine the occurrence of an earthquake, unless it be sufficient to overcome the resistance to displacement. Now, it is unlikely that the *gradual* increase of stress should be so nearly proportioned everywhere to the prevailing conditions of resistance as to give rise to a marked and practically simultaneous change in seismic activity over a large area; whereas the *paroxysmal* occurrence of a strong earthquake might alter the surrounding conditions with comparative rapidity, and so induce a state of seismic excitement in the neighbourhood. (2) The remarkable fault-scarp of the Mino-Owari earthquake was at least forty, and possibly seventy, miles in length; the vertical displacement reached 18 or 20 feet, and the horizontal displacement as much as 5 or 6 feet. A more serious change was "the permanent compression of ground, plots which were 48 feet in length now measuring only 30 feet in length. It appears as if the whole Neo Valley had become narrower."[1] It is clear that crustal distortions of this kind and magnitude could not be effected without a very considerable change of stress in all the surrounding country.

My object now is to ascertain how far this change of stress manifested itself by more frequent shocks, and for this purpose

[1] Prof. J. Milne, Brit. Assoc. Rep. 1892, p. 117.

I have made use of Professor Milne's great catalogues of Japanese earthquakes during the eight years 1885–92.[1]

In the first[2] of the accompanying maps, the district in which the Mino-Owari earthquake and its after-shocks originated, is enclosed between the undulating dotted lines. The neighbouring regions whose seismic activity is to be investigated, are bounded by straight dotted lines, and denoted by the letters A, B, C, D, E, F. The



curves represent the distribution of epicentres within and near these areas. In constructing these curves, the map is divided into rectangles whose sides are respectively one-sixth of a degree of latitude and longitude in length, so that sixteen of these rectangles adjoin the north-south side of the map, and twenty-one adjoin the east-west side, the whole map containing, therefore, 336 rectangles. The number of epicentres lying within each rectangle during the eight years mentioned being counted, curves are drawn through the centres of the rectangles in which five and ten epicentres respectively are found; or, when the numbers are not exactly five or ten, through points which divide the lines joining the centres of adjacent rectangles in

[1] Seismol. Journ. of Japan, vol. iv, 1895.

[2] This map is bounded by the parallels 34° 40′ and 37° 20′ of north latitude, and by the meridians 1° 0′ and 4° 30′ west of Tokio.

the proper proportion. The outer curve in each region corresponds to five epicentres in a rectangle, and the inner to ten epicentres.

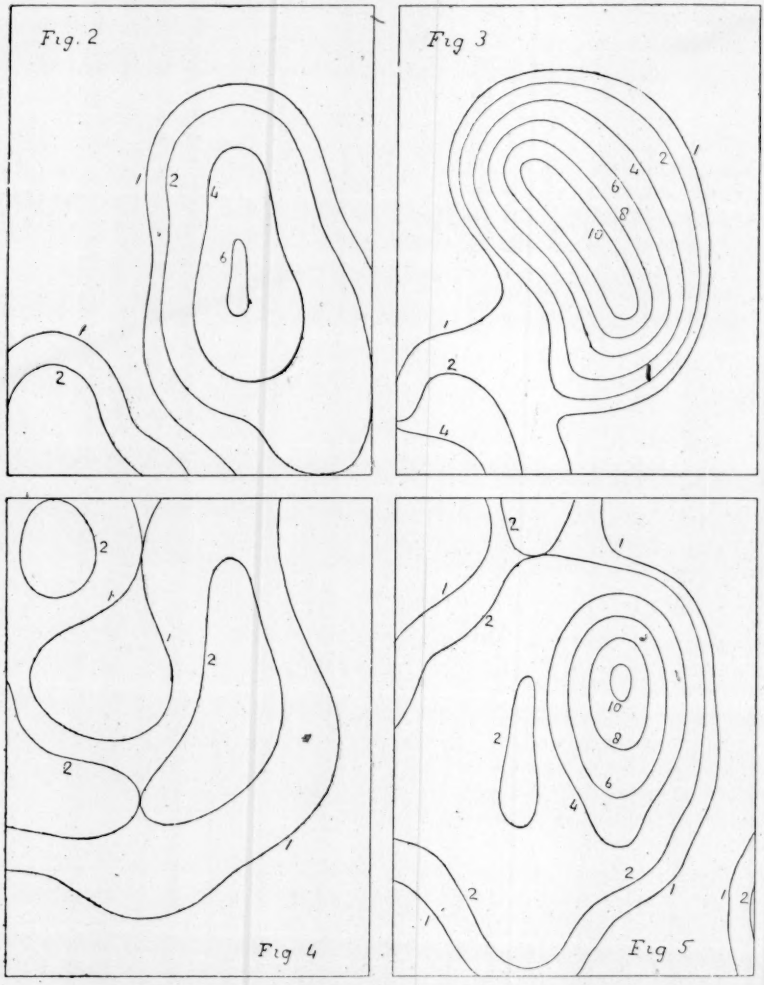
In the central area of Mino and Owari, it will be noticed that the curve of ten epicentres is forked to the south. The great fault-scarp probably begins within the isolated curves in the north part of the area, and follows the east branch of the fork; but there can be little doubt that a second fault traverses the branch proceeding towards the south, though no corresponding scarp was observed upon the surface. The curves in the regions marked D and F seem to point to the existence of a pair of transverse faults, one on each side of the Mino-Owari fault-system, and roughly parallel to it. The earthquakes in the region A are probably connected with a strike-fault, and those in the region B with another transverse fault. The curves marked C and E are too small to offer any reliable guide as to the origin of the earthquakes within them.

In the following table are given the numbers of epicentres which lie within each of these regions, for every year from 1885 preceding the date of the great earthquake (October 28, 1891), and for every month following it until the end of 1892.[1]

	A	B	C	D	E	F
1885	3	2	...	5	7	8
1886	31	18	...	3	4	5
1887	7	4	...	2	1	1
1888	11	4	1	10·5	2·5	4
1889	5	1·5	2·5	1·5	2·5	1
1890	5	2	1	3·5	1·5	1
January 1—October 27, 1891 ...	4	4	1	4	...	0·5
November, 1891...	...	1	3	7	...	8·5
December ,, ...	...	2	1	1·5	...	9
January, 1892	2	1	19	7	...	7
February ,, ...	1	2	...	1	1	3
March ,, ...	...	1	0·5	5	...	1
April ,, ...	...	...	...	2	...	...
May ,, ...	...	...	...	...	...	...
June ,, ...	...	1	...	...	...	1
July ,, ...	...	...	...	...	...	...
August ,, ...	...	...	...	1	...	1
September ,, ...	...	1	8	2	...	1
October ,, ...	...	2	...	4	4	...
November ,, ...	...	1	...	...	...	2
December ,, ...	...	1	...	...	...	3
Number of shocks before the Mino-Owari earthquake ..	66	35·5	5·5	29·5	18·5	20·5
Number of shocks after the Mino-Owari earthquake ...	3	13	31·5	30·5	5	36·5
Ratio of average annual number of shocks after, to the average annual number before, the Mino-Owari earthquake ...	0·3	2·1	33·5	6·1	1·6	10·4

[1] Occasionally an epicentre is defined in Professor Milne's catalogues as lying between two consecutive rectangles. In these cases I have counted half with each, and this accounts for the occurrence of fractional figures in the table.

The last line of the table shows that in every region but one (namely A) the frequency of shocks after the Mino-Owari earthquake is greater than it was before. In two other regions, B and E, the shocks during the succeeding fourteen months were relatively twice and one and a half times as numerous as during the preceding



seven years; but the change is perhaps too slight to have much significance. It is greatest of all in the region C, but this is chiefly due to the large numbers of shocks which occurred during the months of January and September, 1892; and it is uncertain how far these were connected with the Mino-Owari earthquake.

It is in the regions D and F, those nearest the central area, that the change of frequency is most marked; and, as it takes place during the month following the great earthquake, it is difficult to resist the impression that the relation between them is one of effect and cause. The frequency curves for these two districts are shown in greater detail in Figs. 2–5. They correspond to 1, 2, 4, 6, 8, and 10 epicentres per rectangle. Figs. 2 and 3 refer to the region D, and illustrate the distribution of epicentres during the epochs preceding and following the principal earthquake, namely, from January 1, 1885, to October 27, 1891, and from November 1, 1891, to December 31, 1892. Figs. 4 and 5 relate to the region F for the same two epochs. The apparently aimless character of the curves during the earlier epoch in the region F, and their more definite form during the later in both regions, seem to me to point to the advent of new conditions governed by a simple law; and, in my opinion, there can be little doubt that the change was determined by the great earthquake of 1891.

V.—The "Great Submergence" Again: Clava.

By Dugald Bell, F.G.S.

A FEW years ago, in one of three or four papers treating of the "high-level shelly clays" of Scotland, I referred at some length to the interesting section at Clava, near Inverness, first described by Mr. Jas. Fraser, C.E., and inquired—Is it part of an old sea-shore or bottom, laid down by the sea where we now find it, and therefore proving a submergence of at least 500 feet?[1]

I submitted a number of facts and considerations which, I thought, tended to show that this instance at Clava cannot be received as a satisfactory proof of submergence.

Since that time, the Report of the Committee of the British Association on the deposit has been published. It disclosed a difference of opinion on this point among the members, the majority holding that the deposit is really *in sitû*, and indicates a submergence of over 500 feet; while a minority thought the shelly clay may have been transported by land-ice, as in other well-known instances, and that this supposition was attended by fewer difficulties than the theory of a "great submergence."

The subject has again been brought up by Mr. John Smith, who visited the section once while the Committee's investigations were in progress. That single visit has been prolific in results. It enabled Mr. Smith offhand, without waiting for the Report, to instruct the public regarding the deposit; and it enables him now to pronounce, with all confidence, as to which section of the Committee is in the right.[2] As we have no pretension to be so swift and sure in our methods of working, we ask leave, in our old-fashioned way, to go over the ground again, and to restate, as concisely as we can, the

[1] Trans. Geol. Soc. Glasgow, vols. ix, x.
[2] Geol. Mag. for November, 1896.

reasons which appear to us to have weight against the "great submergence" on the one hand, and in favour of the "ice-transport theory" on the other. This is all the more necessary, as, although these reasons have been before Mr. Smith for a considerable time, and were repeated when he read his paper to the Glasgow Society in February last, he wholly ignores them, and publishes his paper now as if it had been received by the members without any words of objection, or any worth noticing.

Mr. Smith's "interpretation" of the section is simply the "old familiar" one of submergence, with some accommodating "currents" of his own, to which we shall afterwards refer. He evidently does not "stickle" at the *degree* of submergence, for he requires, at one stage at least, "*deep water without currents*" at Clava, which we take to imply not only a submergence of fully 500 feet to that point, but not less than 500 or 600 feet more, or, say, over 1000 feet in all. This is a pretty "large order" in the way of a submergence; but Mr. Smith seems to think nothing of it, and hints that he has still larger "orders" on hand for several places in Ayrshire!

(1) Now, the first and most obvious remark about such a submergence (or even one of 500 feet) is, that *if* the sea had reached the level supposed, or anything approaching to it, so recently as in Glacial times, it should have left traces of itself in innumerable localities all over the country. The sea leaves marks of various kinds—wave-worn cliffs, well-marked beaches, beds of shingle, sandbanks, clay-beds, besides organisms of many species, the relics of which are capable of being preserved, more or less perfectly, for very lengthened periods. When some of these evidences are wanting, others are sure to be found, if the sea has really been there.

This is true, not only of the *maximum* elevation, but also of every *intermediate* elevation down to the present sea-level. Both during the progress of the depression, and again during the progress of the re-elevation, such marks and traces of the sea as we have spoken of would be left, and would have a chance—a double chance, so to speak—of being preserved. They should, therefore, be common on our hills and among our glens, in all parts of the country, at the present day.

But, strange to say, whenever we go much above the present sea-level, such marks of the sea and such traces of undoubted marine deposits *in sitû*, are everywhere "conspicuous by their absence." This is a great difficulty, even for a moderate submergence; but it seems insuperable in regard to a "great submergence." The greater the submergence, the wider the area, of course, on which the marks of the sea would be left. It becomes impossible, then, to explain the absence of all such traces, not only at the high level it is supposed to have reached, but at all lower levels at which, in its gradual progress and retreat, the sea must have remained for some time—probably at some of them for a long time—down to the latest well-marked beach above the present shoreline.

(2) This difficulty, while of weight in regard to the country generally, applies with peculiar force to the district around Clava—to the Great Glen in its immediate neighbourhood, and to the numerous side glens and valleys where, as the advocates of submergence themselves admit, traces of the sea, if it had been there, would have had the greatest likelihood of being preserved.

During such a submergence the Great Glen (or Caledonian Canal) and its chain of lakes would form a long, deep, intersecting arm of the sea, stretching from side to side of the country. The highest part of the Canal at Loch Oich is not more than 105 feet above the sea, so that, when the submergence was about 600 feet, the sea must have risen 500 feet along the hills on either side of the summit-level of the Great Glen. At 1000 feet all the hills of moderate elevation would be well-nigh half-submerged; and at the same time, it must have extended far up into every side glen, of which there are many, receiving and spreading out deposits there in every bay and inlet and sheltered recess of the land. And it must have done so for a long time, as those who require a submergence to account for thick deposits of fine clay must admit. How is it, then, that no traces of the sea have been discovered on either side of the Great Glen, at any one of the many elevations which the sea, by hypothesis, reached up to 600, up to 1000 feet? Neither in the main glen, nor in any of the side glens, has a single marine shell-bed, or bed of marine sand and gravel, or slope of wave-worn, cave-hollowed, or perforated rock been detected. The beaches of the old glacier-lakes in Lochaber are still clear as daylight, while the great ocean, sweeping to and fro across the country, and going into every nook and crevice of it, and full of life, has in all these places left "not a wrack behind"!

(3) The supposition that the traces of the sea were removed by a subsequent glaciation was examined on a former occasion, and found to be untenable.[1] Besides, if a subsequent glaciation ploughed out and removed all the marine beds deposited during the submergence (which seems impossible), then the Boulder-clay, the product of that glaciation, should undoubtedly be full of more or less broken and abraded marine organisms, instead of being, as a rule, entirely destitute of them. This has been admitted to be a difficulty which cannot well be got over.[2]

(4) A submergence of 1000 feet, or even much less, must in all probability have extended over a wide area. How far did the supposed submergence at Clava extend? In Caithness there is no evidence of any such submergence. In the southern part of the country the ice has come from the interior *seaward*, and the Boulder-clay there contains *no* shells. In the northern part, owing to the blocked condition of the North Sea, the ice has curved round and been pressed *on* to the land again, and there the Boulder-clay is full of shells and shelly fragments. Similarly, in Aberdeen the

[1] Trans. Geol. Soc. Glasgow, vol. ix, p. 109.
[2] GEOL. MAG., August, 1895.

grey till formed from the native rocks contains no marine organisms, which are restricted to sands and clays containing (like the Caithness shelly Boulder-clay) fragments of rocks foreign to the district, and which seem to have been borne inland along with the shells, etc., from the sea. (See Peach and Horne on the Glaciation of Caithness; Jamieson on the Shelly Clays and Gravels of Aberdeenshire.)

(5) Again, supposing such a depression and collapse of the earth's crust, say over the area of the British Isles, or a great part of it, where is the probability that the sunken part, after some tens of thousands of years (in all likelihood), should re-emerge, presenting much the same aspect as before, the same general arrangement of hills and valleys, the same climatic conditions over again, with very little to show for the prolonged submergence, except a few stray patches here and there of shelly clay, the very paucity and the distribution of which suggest that their present position is due to another cause?

The difficulty is not the submergence alone (though that is sufficient, without the very clearest proof, when one of such magnitude is concerned), but the submergence *plus* the re-emergence that followed.

(6) Another consideration, which has been alluded to more than once of late years, is that such a submergence would in all probability be accompanied by much milder climatic conditions, of which marine organisms found at high levels, if in place, would furnish clear indications. (See Lord Kelvin "On Geological Climate," Trans. Geol. Soc. Glasgow, vol. v.)

We submit that these objections, and others that might be stated, ought to be considered and answered in some degree before we are asked still to accept the old, crude, "rough and ready" theory of a "great submergence." It is worthy of note, ere leaving this part of the subject, that the objections which have been urged, of late years especially, to such a submergence in this country are precisely similar to those which the American geologists have urged with unanswerable force in regard to certain high-level terraces that were formerly supposed to be sea-beaches, but are now clearly made out to be old lake-margins. A general subsidence of the country was the theory formerly adopted. But as Professor G. F. Wright states the case—"There is no such amount of collateral evidence to support the theory of general subsidence as there should be if it had really occurred. The subsidence of the lake region to such an extent would have left countless other marks over a wide extent of country, but such marks are not to be found. Especially is there an absence of evidences of marine life. The cause was evidently more local than that of a general subsidence." ("Ice Age in North America," p. 353.)

In our next we shall consider the *pros* and *cons*—especially some of the alleged *cons*—of the alternative, or ice-transport, theory.

VI.—British Geological Photographs.

By W. W. Watts, M.A., F.G.S.

A YEAR ago, by the decision of the Council of the British Association, there was sent to the Museum of Practical Geology a large collection of photographs mainly taken with a view of illustrating, in the most permanent and unbiassed way at present possible, the features and phenomena of geological interest in the United Kingdom. The project of forming such a collection originated with Mr. O. W. Jeffs in 1888, when he read a paper on the subject at the British Association at Bath, in which he pointed out the utility of such a collection and the necessity for forming it. When a committee was appointed in the following year he undertook the management of the work, and he has carried it on for seven years with indefatigable industry and scrupulous care, only relinquishing it when the size of the collection began to exceed the capabilities of private control, and when his own lack of leisure no longer permitted him to devote the requisite time and attention to its custody. Twelve hundred photographs had been acquired by 1895, and it was then thought advisable that the collection should be lodged in the Library of the Museum of Practical Geology, where it would be available for reference by all those who wished to make any real use of it.

The year that has just elapsed has been occupied in cataloguing and rearranging the collection so as to make it more easy of access and reference. This has been rendered possible by the adoption of self-binding mounts of standard size (15½ in. by 12 in.), which can be shifted into different portfolios as required. The work is now far advanced towards completion, but the necessary remounting of the earlier part of the collection is a matter of time and expense, so that it may not be quite finished even within the present year. Still, the most valuable part is that which is being dealt with first; and only those districts which are already well illustrated, and even in some cases over-illustrated, are being left until a later period.

It has been thought worth while at this stage to publish some account of the purposes of such a collection, to describe the character of what has been already brought together, and to indicate the directions of future development; for it must at once be stated that finality has been by no means reached yet, and there is a great deal of work which ought to be completed in the next few years before the whole country will be well illustrated, and before, so to speak, sufficient capital has been created to enable the collection to exist on its average income.

The objects of the collection can soon be stated. It is obvious, in the first place, that it is well to have geological phenomena of all sorts photographed: pictures so taken, under proper precautions, are entirely trustworthy; the personal element can hardly enter into them, and they as a rule present the bare facts denuded of the halo of interpretation. A paper by Mr. Cope Whitehouse on Fingal's

Cave presses home this truth, and makes a good deal of fun out of the old illustrations and drawings of this curious feature when compared with a photograph. The comparison is quite justifiable when and where photographic illustration is possible, and one would be only inclined to point out that, not a single photograph, but several, are usually required, so that the thing may be seen in the solid and not in one plane, and that drawings are, and always will be, the necessary adjunct to the photograph if we are to interpret as well as see. Very many phenomena readily submit to photographic treatment, and though the first qualifications of a geologist should be travel, and travel, and again travel, he cannot see everything, and even the most experienced traveller may be guided and helped by seeing photographs before he visits a place, and may correct his impressions by means of them when he comes back, or, if he himself does not need such an aid, they may at least be useful to him in convincing his friends who have not been so fortunate. How we should like to have, for instance, a photograph marked by Salter himself, to show exactly where he drew his line between the Caradoc and Llandovery rocks, or of some of the older type fossils which it is so hard to recognize in our museums.

It is still more important to preserve such photographs as have been used to produce process blocks for scientific purposes, or as a basis for the preparation of drawings; the committee has already begun this work, and proposes to continue it if the friendly aid of editors of geological publications can be secured. As an example of what can be done we may refer to the splendid series of photographs of the dry valleys about Clapham in Yorkshire taken by Mr. Bingley to illustrate Mr. Tate's paper in the Proceedings of the Yorkshire Geological and Polytechnic Society. This is but one of the more recent examples, but many others might be quoted. Microphotographs of organisms and rock sections, views of quarries, boulders, glaciated surfaces, pebbles, structures in aqueous, igneous, and foliated rocks, and a host of other things, frequently reproduced by process or drawings, ought to be represented in this collection by permanent prints from the original negatives.

Again, for educational purposes it would be a very good thing to replace many of the venerable drawings which have so long done duty in the textbooks for representations of unconformity, bedding, dykes, cleavage, joints, faults, contortions, and many other elementary phenomena, by reliable photographs representing the actual facts as the student will really see them. When the collection has further advanced it should be possible to make a very perfect selection from it to illustrate such points, but hitherto it has not been large enough for the purpose, nor has any publisher been found willing to undertake the risk of reproducing such a set of illustrations, although it has often been asked for by those engaged in teaching. It is true that it is not so difficult to obtain illustrative photographs as it once was, and there are some educational series issued by professional and skilful photographers in England, Scotland, and especially in Ireland, which provide a great deal that is required; it is not quite

inconceivable that the influence of the collection has had something to do with bringing about this result. But much of the work of amateurs is not at present available for this purpose, although it is superior to all but the very best professional work in the facts it delineates, albeit usually inferior in technical execution. As the committee's work progresses it should be possible to indicate where pictures of the most typical examples of rock-structure, features of landscape, phenomena of denudation and deposit, glacial action, etc., are to be obtained, even if it should still not be possible to reproduce them by process in a collected form.

The element of time enters into the interest of this collection in at least two ways. Firstly, we may sometimes register the effects produced by geological causes during the lapse of years. The advance of the sea at Reculvers would impress us even more than it does in the two drawings copied in Lyell's "Principles," if he had been able to give two photographs taken from the same spot instead. In Britain we cannot register such physiographic changes as the destruction and rebuilding of volcanic cones, the uprise and downfall of the sea, the effects of great earthquakes, the advance and retreat of glaciers, and the like; but we have landslips, floods, the filling up of lakes and estuaries, the advance of sand-dunes, and erosion by streams, seas, waterfalls, and wind.

One of Miss Andrews' photographs shows an unexpected instance of this kind: a pump erected in 1824, to get the water out of a stone quarry near the coast in County Down, is now to be seen 50 feet out at sea; and one by another hand shows that the shaft at the back of an old cave by which smugglers used to pass their ill-gotten goods inland is now at the mouth of the cave, and all but cut away by the general wear and tear of the coast, while the cave itself has been worked back. Others show in minute detail the outline of the coast at Filey, Flamborough, Sunderland, etc., so that it will be possible to see the progress of future denudation by comparison with them.

On the other hand, the duration of exposures of geological features is often only temporary: railway cuttings become grassed over, quarries abandoned and closed, trenches and subterranean works filled up and built over, rock exposures soiled over and planted, or even submerged, boulders are broken up and disappear, sea cliffs are worn back or hidden by landslips. All these things might be preserved on paper, so that it is possible to check conclusions founded on them by reference to photographs even when they are no longer open to examination. The Cambridge Greensand is becoming an unseen stratum, the Crags are gradually disappearing, gravel beds and road-metal quarries are being worked away, stones formerly much worked are being abandoned; records in the form of photographs as well as descriptions ought to be kept. Sir H. T. Wood's photographs of the excavations in the Beer-stone, I believe, show features no longer to be seen; and the photographs of the stages of working of the great quarries at Bardon and Mount Sorrel preserved in the collection will be of interest to those who read the

papers on Charnwood Forest, and even of greater interest to those in the future who shall find nothing but holes and talus heaps where the hills now stand.

Discussion at the Geological Society as to whether a bed dips this way or that, whether one rock is or is not intrusive into another, or on the nature of the junctions of strata, would occasionally have their acerbity softened by the exhibition of photographs which gave a true picture of the facts, while the record established by such photographs might serve as useful if, perhaps, at times inconvenient reminders.

The present collection contains many fine sets of views taken in series so as to illustrate particular points. Beginning with the north of England, the coast north and south of Tynemouth, for a considerable distance, has been photographed, including the Whin Sill and its contacts, the Carboniferous rocks, and the Magnesian Limestone, with its breccia-gashes and other beds of concretions about Marsden and Sunderland. Passing inland, we also owe to Mr. Garwood a very beautiful set of photographs illustrating with the greatest clearness the character and history of the Whin Sill and of the northern boulder-clays. In their own county Mr. Bingley and other members of the Yorkshire Naturalists' Union have given us a series, which it is to be hoped will eventually be completed, that serves as a picture survey of the coast, while inland we have the Clapham, Norber, Gordale, and other districts thoroughly represented.

Of the Eastern Counties we have very little, and that chiefly of Norfolk, but we have been promised a series, specially taken for our purpose, of the Crag district and parts of the eastern coast-line. Of the Home Counties, again, we have little; and of the characteristic scenery of the Weald there is not much to be obtained at present, in spite of the work of the East Kent Society, to which we owe most of what we have. Of Surrey we have little, of Sussex nothing, and of the Isle of Wight not nearly enough; but the Dorset coast and inland regions have been well treated by Mr. Cole, Mr. Bingley, Miss Andrews, and others. Parts of Devon and Cornwall have been dealt with in detail, but the prints have not yet been satisfactorily described and illustrated, partly, no doubt, on account of our limited knowledge of the minuter geology of these counties. Somerset has been treated by Professor Allen, Mr. Armstrong, and others, and its main features have been illustrated, but all that is necessary has not yet been done.

In the South Midland Counties, from Hertfordshire to Gloucestershire, but little has been collected, though Mr. Hopkinson has striven, by example and precept, to show what there is to do and how to do it. South and Central Wales, with the border counties of Hereford and Monmouth, are almost virgin fields. Of North Wales there are some capital photographs, including those of the Llanberis district, by Mr. J. J. Cole, but there is much still to be done in a country so rich in evidences of glaciation, with fine rock-structures, types of mountain form, and wealth of outcrop of rocks not so well seen elsewhere. The Ordovician ground of Shropshire has been

illustrated, but much remains to be done in the Silurian and pre-Cambrian country, and amongst the newer rocks of the east and north; the same may be said of the counties of Stafford, Derby, and others of the North Midlands, except in Leicestershire, where, owing to the energy of the Leicester Philosophical Society and a few others, a great deal has been effected in some parts of the county, particularly in the classic ground of Charnwood Forest. Cheshire and Lancashire have been taken in hand by the Liverpool Geological Society, but much remains to be done in the large counties of Cumberland and Westmoreland, and especially in Lakeland. Something has been done in the Isle of Man, but the recent Survey work there requires photographic illustration.

Passing to Scotland, the more sensational regions of the lava plateaux have been illustated by numerous sets, but the ground of gneiss and schist in the North-West and of the Central Highlands requires much new work; the same might be said of the greater part of the Central Valley and the Southern Uplands. Mr. Kidston has done good work in Stirling, Mr. Coates in Perth, and Mr. Goodchild about Edinburgh, but not much other systematic work has been attempted. The names of Professor Heddle, Mr. Harvie Brown, Mr. Howie, and Messrs. Valentine, should be mentioned as having contributed to the Scottish part of the collection.

In Ireland, the Belfast Naturalists' Field Club was one of the first of the field clubs to undertake the definite collection of a set of photographs to illustrate their own district, and to contribute the proceeds to the central body; their able contributors, amongst whom it is a pleasure to name Mr. Welch, Miss Andrews, Mr. Gray, and Mr. Stelfox, have done much towards a photographic survey of their own county and those bordering it. Dr. Valentine Ball was instrumental in sending a set of prints illustrating the phenomena of the ancient rocks on Howth, near Dublin, while Dr. Tempest Anderson and Mr. Bingley have done much good work. The rest of the work may be safely left in the hands of those energetic field clubs which have begun so well, with the remark that such districts as the Wicklow Mountains, the beautiful tract of Limerick, the areas of ancient rocks in Galway and Mayo, and the Carboniferous and Old Red Sandstone rocks of Kerry, are all, literally, awaiting development.

In England and Wales we would call especial attention to the further photographing of the big boulders and ice-worn rocks which are rapidly disappearing, to the Malverns, the Cheltenham Oolites, and those of Dorset and Wiltshire with their Cretaceous rocks, the central Coalfields of England, the Lake Country and the Cheviots, the Dale district of Yorkshire, and the Southern and Central parts of Wales.

The future extension of the collection, like its past history, must depend very largely on the local societies and field clubs. These bodies are always asking what work they can do that will employ a good number of their members, and which, though not requiring too much technical knowledge, will really be a help in advancing natural knowledge. This is the very class of work required, and

many of the societies have thrown themselves heart and soul into it. Many of them have already been mentioned in connection with the districts in which their work lies, but there are several others, such as the Chester Society of Natural Science, the Croydon Microscopical Society, the Dover Natural History Society, the Geological and Geographical Societies of Manchester, and the Geologists' Association, which have given ready help. Warwickshire has carried out a Photographic Survey of its dominions, including not only geological phenomena, but subjects of geographical, ethnographical, and archæological interest. It may not be yet possible to carry out such a comprehensive scheme as this in many cases, but it ought not to be difficult to get one or two enthusiastic photographers in each county to register at least the prominent and temporary features and phenomena of geological interest. Guidance and help, where it was needed, would be forthcoming from local geologists and the Survey, and it may be possible in the compass of a few years to have the whole of the United Kingdom fairly well represented, so that there would only remain the task, which will then have become an easy one, to photograph new sections as they are exposed, and new phenomena as they are recorded and understood. We should thus become possessed of a storehouse of fact to which the rising geologist can readily turn to see the state of knowledge at this particular date, to check the older work, and to measure the progress of physiographic change.

Our present experience with the collection shows that one of the great dangers which exists is the want of permanence of some of the prints. Kept away from the light as most of them are, it seems that the ordinary silver prints last fairly well when properly fixed and washed after toning; bromide prints, however, appear to last better, and, of course, platinotypes best of all. It is really worth while to sacrifice some of the depth and detail of shadow, at present an unavoidable defect of platinotype printing, in order to secure the greater permanence which these prints give. To those who take small prints it may also be said that enlargements are very satisfactory from the greater ease with which they can be studied; but it is advisable, by the use of a small stop or a very good lens, to get the negatives from which enlargements are to be prepared as sharp and clean as possible. Very good results are obtained by carbon enlargements, but the process is troublesome owing to the necessity for preparing an enlarged negative; still, such a negative is a valuable acquisition when once it has been made.

Every photographer knows the importance of illustrative drawings taken at the same time as the photograph, or, better still, with the photograph in hand when the section is revisited; such careful work as this adds immensely to the value of the photographs as a permanent record.

Some attempt has been made to make the photographs more accessible and useful by promoting exchange between contributors, and the Committee can always be utilized as a means of intercommunication; some photographers have been kind enough to

place their negatives in the hands of professionals, from whom lantern slides and prints can be obtained on paying the expense of production. It would, however, be far too large a task for the Committee to undertake any further action in this matter or to assume the copyright of prints sent to them; this must remain in the hands of the original photographers, and arrangements must be made with them in each case.

In conclusion, I feel impelled to add a word about the regulations and forms issued by the Committee, which have been objected to in some quarters. In the first place no hard and fast rules are insisted on; only certain *hints* have been drawn up as they were suggested by the experience of the Committee, now somewhat considerable. Uniformity in size is unattainable, nor is it at all necessary with the present system of mounting, but the larger photographs are, up to whole plate size, the more easily they can be examined. Larger ones, up to 15 in. by 12 in., can be accommodated. For the reasons given before, permanent prints are obviously more likely to be useful to posterity than others. A scale of some sort, no matter what if its size is given, where necessary, in the explanatory form, is really required in order to impress the scale of the structure photographed; the human figure does very well—a hammer of stated size is convenient in smaller views if it is placed so that its entire length lies at right angles to the line joining the camera with the centre of the picture; an umbrella or walking-stick is quite satisfactory; or it suffices to indicate the length of some portion of the section, easily recognizable in the print, on the accompanying form. The use of the standard descriptive forms is very desirable; they are mounted with the photograph, and if the chief details are filled in they enhance its value enormously. It is very important that these forms should be sent, filled in, with the photographs to ensure absolute accuracy, and, although it is not necessary to attend to all the minute details for which space is provided, some of them, like the date (at least the year, and when possible the month) and the exact location, so that the place could be found again, should be carefully given. It has recently been my lot to fill in some hundreds of these forms for other people, and this has led me to appreciate the labour involved, but it has only convinced me more completely of the necessity for them, and that they should be filled up by those who know the locality and its geology well.

I am hoping to have a number of the older photographs looked over, as opportunity occurs, by those who are most familiar with the localities in question, so as to bring out to the fullest extent at present practicable the latent value and interest of the whole collection.

Note.—By the kindness of Mr. W. W. Watts we hope, next month, to be enabled to give one or two good illustrations in order to show the value of the work which is now being carried on by the British Geological Photographs Committee, initiated by Mr. O. W. Jeffs and carried on so successfully by him and by the Committee during the past nine years.—Edit. Geol. Mag.

REVIEWS.

I.—The Dinosaurs of North America. By Othniel Charles Marsh. (Extract from the Sixteenth Annual Report of the Survey, 1894–5. Part I: Director's Report and Papers of a theoretic nature. Department of the Interior, U. S. Geological Survey; Charles D. Walcott, Director.) Imperial 8vo, pp. 135–244, pls. ii–lxxxv. (Published at the Government Printing Office, Washington, 1896.)

THE name and researches of Professor O. C. Marsh are already familiar to the readers of the Geological Magazine, and his papers on the Dinosauria have been largely illustrated in its pages during the past fourteen years.[1] The publication, therefore, of the present Survey Memoir can hardly be expected to add much to the knowledge which we have already derived from the author's numerous and well-illustrated separate memoirs, which have from time to time been issued from Yale University, Newhaven, Connecticut. In the present volume we have brought together, into one focus, all the work Professor Marsh has done on the Dinosauria, but even now, many fine plates are held back for a further *edition de*

[1] The following is a list of Professor Marsh's papers on Dinosaurs in this Magazine:—

(1) "Classification of the Dinosauria," O. C. Marsh: Geol. Mag. 1882, pp. 80–5.
(2) "American Jurassic Dinosaurs—Restoration of *Brontosaurus*," O. C. Marsh: op. cit., 1883, pp. 385–8, Pl. IX.
(3) "On the Diplodocidæ (Family Sauropoda)": op. cit., 1884, pp. 99–107, with Ten Woodcut Illustrations (four views of skull of *Diplodocus*, etc.).
(4) "The Principal Characters of American Jurassic Dinosaurs, of the order Theropoda": op. cit., 1884 (Eight Illustrations of *Ceratosaurus* and *Allosaurus*).
(5) "The Skull and Dermal Armour of *Stegosaurus*": op. cit., 1888, pp. 11–15, Pls. I, II, III, and Three Woodcuts.
(6) "Comparison of the Principal Forms of Dinosauria of Europe and America": op cit., 1889, pp. 204–10.
(7) "The Skull of the Gigantic Ceratopsidæ": op. cit., 1890, pp. 1–5, Pl. I (*Triceratops flabellatus*, Marsh).
(8) "The Gigantic Ceratopsidæ or Horned Dinosaurs of North America": op. cit., 1891, pp. 193–9, Pls. IV and V, and Figs. 1–17, in text (*Triceratops prorsus*).
(9) "Restoration of *Triceratops prorsus*, Marsh": op. cit., 1891, pp. 248–50, Pl. VII (Restoration of the Skeleton of *Triceratops prorsus*, Marsh).
(10) "Restoration of *Stegosaurus ungulatus*, Marsh": op. cit., 1891, Pl. XI, pp. 385–7.
(11) "Restorations of *Anchisaurus*, *Ceratosaurus*, and *Claosaurus*, Marsh": op. cit., 1893, pp. 150–7. (Fig. 1, *Anchisaurus colurus*; Pl. VI, *Ceratosaurus nasicornis*; Pl. VII, *Claosaurus annectens*.)
(12) "Restoration of *Camptosaurus dispar*, Marsh": op. cit., 1894, pp. 193–5, Pl. VI.
(13) "Restorations of some European Dinosaurs, with Suggestions as to their place among the Reptilia," by O. C. Marsh: op. cit., 1896, pp. 1–9. Pl. I, *Compsognathus longipes*, Wagner; Pl. II, *Scelidosaurus Harrisoni*, Owen; Pl. III, *Hypsilophodon Foxii*; Pl. IV, *Iguanodon Bernissartensis*, Boulenger.
(14) "Classification of Dinosaurs": op. cit., 1896, pp. 388–400, with twelve restorations of dinosaurs, to scale, in the text, namely: 1, *Anchisaurus*; 2, *Compsognathus*; 3, *Ceratosaurus*; 4, *Brontosaurus*; 5, *Stegosaurus*; 6, *Scelidosaurus*; 7, *Triceratops*; 8, *Camptosaurus*; 9, *Laosaurus*; 10, *Hypsilophodon*; 11, *Iguanodon*; 12, *Claosaurus*.

luxe, which we hope the learned author will not long postpone to bring out.

In his brief Introduction, the author tells us that the true place of the Dinosauria in the animal kingdom has been a matter of much discussion amongst anatomists, but the best authorities now regard them as constituting a distinct subclass of the Reptilia. Some of the large, earlier forms are apparently related to the Crocodilia, while some of the later small specialized ones have various points of resemblance to birds. These diversified characters make it difficult to classify the dinosaurs among themselves, and have led some writers to assert that these reptiles do not form a natural group, but belong to divisions remotely connected, and not derived from a common ancestry.

Without discussing in detail the classification of this group, it may be stated in a few words that three great divisions of the Dinosauria are generally recognized, which may be properly regarded as distinct orders. For these groups the author has proposed the names THEROPODA for the one including the carnivorous forms, and SAUROPODA and PREDENTATA for the two herbivorous groups, the last order being made up of three separate suborders, namely, the Stegosauria, the Ceratopsia, and the typical Ornithopoda. The first of these suborders contains large dinosaurs, more or less protected by a dermal covering of bony plates; the second group includes the huge horned dinosaurs; and the third is made up of the forms that in shape and structure most nearly resemble birds.

Commencing with the Triassic deposits, we find that a dinosaur (*Clepsysaurus Pennsylvanicus*, Lea) was made known from a few bones, found in 1847, and described by Dr. Isaac Lea in 1851; and a jaw with teeth, named *Bathygnathus borealis* by Dr. Leidy, from Prince Edward Island, Canada, was described in 1854 (Journ. Acad. Nat. Sci. Philad. 1853 and 1854). A third, named *Megadactylus polyzelus*, was discovered by the veteran Professor E. Hitchcock in 1856, and described in 1865 by his son, E. Hitchcock, jun.

A nearly complete carnivorous dinosaur was discovered in 1884 in the same Connecticut River series of Triassic age, and named by Marsh *Anchisaurus colurus* (see plates ii, iii, iv, op. cit., and GEOL. MAG. 1893, Fig. 1, p. 150). The foot of another Triassic form (*Ammosaurus*) is also figured, and reference is made to dinosaurian Triassic footprints, the so-called "bird-tracks" of the Connecticut River series. The occurrence of *Thecodontosaurus* in the Trias of Bristol (England), and *Plateosaurus* (*Zanclodon*) in Germany, completes the European and American Triassic forms, but other remains have been found in India, in South Africa, and in Australia.

In the Jurassic strata of Colorado, Professor Marsh has discovered a small Theropodous dinosaur of carnivorous habits, about the size of a rabbit, in which the metatarsals of the hind-limbs are greatly elongated, suggesting the generic name of *Hallopus*, or leaping-foot, from its probable mode of progression. In another higher stratum of the Colorado series the genus *Cœlurus* is met with, of the same

small type as *Hallopus*. Both these are probably near relatives of *Compsognathus*, from the Lithographic Stone of Solenhofen (plate lxxxii; and GEOL. MAG. 1896, Pl. I, and p. 392, Fig. 2). These are among the smallest of the class.

One of the largest carnivorous forms was *Ceratosaurus* (*C. nasicornis*, Marsh), measuring some 18 ft. in length and standing nearly 15 ft. from the ground. It had a horn-core on the nasal bone; the bones of the pelvis are all co-ossified, as in existing birds; the metatarsal bones are also co-ossified, a feature characteristic of birds, but not known hitherto in any other dinosaur. The premaxillaries each contained three, and the maxillaries had each fifteen, large, powerful, and trenchant teeth, clearly indicating, as in our own Oolitic *Megalosaurus*, the ferocious character of the animal.

Of the other carnivorous dinosaurs of the American Jurassic, three genera, *Allosaurus*, *Creosaurus*, and *Labrosaurus*, are specially worthy of notice. All were represented by species of large size, the natural enemies of the gigantic herbivorous forms that were so abundant in the same period. All had powerful jaws, sharp, cutting teeth, and a flexible neck. The fore-limbs were quite small, and the feet (manus and pes) were armed with strong claws for seizing living prey. The hind-limbs were large and strong, and the animals used them alone in ordinary locomotion.

The herbivorous dinosaurs of the American Jurassic are of special interest, comprising in the SAUROPODA the most primitive and gigantic forms, and also one of the most diminutive, *Pleurocœlus*. The Atlantosauridæ include the largest forms; the Diplodocidæ and Morosauridæ are both represented by gigantic species; whilst the small Pleurocœlidæ appear to be the last survivors of the order in North America.

Remains of the first three families are abundant in the *Atlantosaurus* beds of the West; and the locality near Lake Como, in Wyoming Territory, has now become one of the most famous in the entire Rocky Mountain region, having yielded to Professor Marsh remains of several hundred dinosaurs.

Atlantosaurus is only known from imperfect remains, but the pelvic bones and femur of *A. immanis* give an idea of its gigantic size. The femur is over 6 ft. in length, and this, with the other portions of the skeleton, indicates, says Marsh, an animal about 70 or 80 feet in length! *Apatosaurus* is a nearly allied genus. In *Brontosaurus*, the type-specimen being a nearly entire skeleton, we obtain by far the most complete and accurate knowledge of any of the SAUROPODA yet discovered. In *Atlantosaurus* and *Apatosaurus* there are only three coalesced sacral vertebræ, in *Brontosaurus* there are five. Although about 60 ft. in length, its skeleton is distinguished by the peculiar lightness of its vertebral column, the cervical, dorsal, and sacral vertebræ all having very large cavities in their centra; the first three caudals, also, are lightened by excavations in their sides.

The head of *Brontosaurus* was remarkably small; the neck was

long and flexible, and was the lightest portion of the vertebral column. The body was short, and the abdomen of moderate size. The legs and feet were massive, and the bones of the limbs all solid. The feet were plantigrade, and each footprint must have covered about a square yard! The tail was large, and nearly all the bones were solid. The very small head and brain and the slender neural cord, indicate a stupid, slow-moving reptile. The beast was wholly without offensive or defensive weapons or dermal armature. *Barosaurus* is an allied form. Of European forms *Cetiosaurus longus*, from the Great Oolite, Oxford, *Ornithopsis Hulkei*, from the Wealden of the Isle of Wight, have the skeleton constructed like *Brontosaurus*, with the same large cavities in the centra of the vertebræ. The teeth named *Hoplosaurus armatus*, Gervais, from the Wealden, Isle of Wight, are also identical in form with those attributed to *Brontosaurus excelsus*, Marsh.[1]

One of the most remarkable heads of any of this curious group is that of *Diplodocus*, which, when seen in profile, forcibly recalls the expression of the "Mock-turtle" by J. Tenniel, in "Alice in Wonderland." The orbits are large and placed far back in the cranium; the facial portion is elongated and broadened in front; the nasal opening is very large and placed near the apex of the skull. The teeth, which are very weak, slender and cylindrical in shape, resemble a row of bluntly-rounded pins; they are all crowded to the front of the jaws, 4 in each premaxillary and 9 in each maxillary = 26 above, and 10 in each dentary of the lower jaws = 46 in all. A section of the maxillary bone shows provision for an abundant succession of new teeth when required, and from their shallow insertion they would probably have been readily detached. No restoration is given of *Diplodocus* save of the skull; but the beast was probably intermediate between *Atlantosaurus* and *Morosaurus* in size, and from 40 to 50 feet in length. The teeth indicate an herbivorous diet, the animal feeding largely upon succulent vegetation, and the position of the nares seems to indicate an aquatic mode of life. *Morosaurus* is placed near to *Diplodocus*. The limbs suggest a plantigrade progression, as in *Brontosaurus*. There does not appear to be any representative of *Diplodocus* out of North America.

In the division named by Marsh the PREDENTATA, all the members have a predentary bone (called by Hulke the presymphysial bone), which is absent in all other dinosaurs, but is present in fishes of the genera *Aspidorhynchus* and *Belonostomus*. This order includes the Stegosauria (or plated lizards), the Ceratopsia (or horned lizards), and the Ornithopoda (or bird-footed dinosaurs). All these are herbivorous forms.

Stegosaurus probably rivalled *Brontosaurus* and the other non-plated dinosaurs in size: all its bones, however, were solid; the vertebræ were biconcave; its body was defended by strong compressed dorsal bony spines and plates, which in life were encased in horny sheaths; its head was very small in proportion to the size of the entire animal, whilst its brain was only $\frac{1}{100}$ that of an

[1] Similar remains have been met with in Madagascar and in Patagonia.

alligator, if the weight of the entire animal be brought into comparison; indeed, it may be said to have had one of the smallest brains of any known land vertebrate. The teeth are small, with compressed, fluted crowns, separated from the roots by a more or less distinct neck. Owen's genus *Omosaurus*, from the Kimmeridge Clay of England, cannot be separated generically from *Stegosaurus*. *Scelidosaurus*, from the Lias of Charmouth, also agrees with it in the structure of its teeth and in the possession of dermal armour.

In *Camptosaurus* we have a form of dinosaur which in general appearance resembles the *Iguanodon* from Bernissart. The sternum in *Camptosaurus*, however, is entirely unossified, and no trace of clavicles has been found. In the manus of *Camptosaurus* there are five functional digits, the first being flexible and parallel to the second, not stiff and divergent like the thumb of *Iguanodon*. The pes (hind-foot) has three functional digits only, the first being rudimentary and the fifth entirely wanting (as shown on plate lvi). It is a more slender form than *Iguanodon*. *Dryosaurus* is a genus allied to *Camptosaurus*, also from the *Atlantosaurus* beds of Colorado and Wyoming.

Laosaurus is a diminutive dinosaur possessing many avian features, now only seen in existing, and more especially in struthious, birds. The European representative of *Laosaurus* is the *Hypsilophodon Foxii* of the Wealden of the Isle of Wight. *Nanosaurus agilis* is the name given to another, quite small dinosaur, allied to the foregoing, having strong bird-like characters in its anatomy.

The Ceratopsidæ, or huge horned dinosaurs from the Cretaceous rocks, are an outcome of Converse County, Wyoming, where, in a limited area near the Cheyenne River, Mr. J. B. Hatcher found more than thirty specimens. In the largest individuals the skull (in *Triceratops*) exceeds that of any *land* animal hitherto discovered, living or extinct, and is only surpassed by some of the marine Cetacea. One head, when complete, must have been 7 or 8 feet long. Two others, nearly perfect, from the same horizon, have equal or still greater dimensions. Another striking feature is its armature. This consisted of a sharp cutting beak in front, a strong horn on the nose, a pair of very large pointed horns on the top of the head, and a row of sharp projections around the margin of the posterior crest. All these had a horny covering of great strength and power. For offence and defence they formed an armour for the head as complete as any known. In some forms the armature extended over portions of the body. The skull is wedge-shaped in form, the facial portion being very narrow in front, and prolonged; the frontal region is massive and greatly strengthened to support the large and lofty horn-cores which formed the central features of the armature. The huge, expanded, posterior crest, which covered the back of the skull and overshadowed the neck, afforded attachment to the powerful ligaments and muscles that supported the head. Several other genera, as *Torosaurus, Ceratops, Sterrholophus, Agathaumas, Polyonax*, and *Monoclonius*, are referred to, and the first two are figured. One

feature of interest must not be omitted; it is that the teeth have *two distinct roots*: this is true both of the upper and lower series. The roots are placed transversely in the jaw, and there is a separate cavity, more or less distinct, for each of them. No fewer than ten vertebræ are co-ossified in the sacrum of *Triceratops*; whilst the middle, or true sacral vertebræ, have double transverse processes to support the ilium—a character hitherto only seen in *Ceratosaurus* and other Theropoda.

Another American type of dinosaur is represented by the genus *Claosaurus*, from the Cretaceous of Kansas.

The skull is long and narrow, with the facial portion especially produced, and slightly expanded in front, very like the head of an anserine bird when seen from above. The extremities of the premaxillaries are beak-like, and the predentary bone is robust and fitted to meet the strong beak above. The teeth in *Claosaurus* are confined entirely to the maxillary and dentary bones. They are very numerous, and are arranged in vertical series, so that they succeed each other as the functional teeth are worn away. The number of teeth, as shown in the drawing, may be as many as 38 to 40, above and below, on each side, if they are correctly shown on pl. lxxii, fig. 1; but "*six* or more" is the number mentioned in the text on p. 221 (this should probably be 66).

The whole vertebral column was found *in position*, except the terminal caudals, which are represented in outline. The first and second caudals have no chevrons. Behind these the chevron-bones are very long, indicating a powerful, compressed tail, well adapted for swimming.

Between the ribs and the neural spines, in the median dorsal region, are very numerous rod-like ossified tendons, which increase in number in the sacral region and along the base of the tail, and then gradually diminish in number and size, ending at about the 35th caudal. These tendons resemble those in the Bernissart *Iguanodon* described by Dollo, and must have added greatly to the strength of the dorsal region in these old vegetable-feeding dinosaurs, whether in raising themselves into an erect position, or to assist them in the act of running, or swimming, to escape from their carnivorous enemies.

The fore-limbs of *Claosaurus* are unusually small in comparison with the posterior. The manus was very long, and had three functional digits: two (2nd and 3rd) were of equal length, but the 1st was rudimentary, the 4th was shorter and less developed, and the 5th was entirely wanting. The ends of these phalanges were blunt, and were probably covered with hoofs and not with claws. The hind-foot, or pes, had but three digits (as in *Iguanodon*), and the terminal phalanges were covered with broad hoofs.

In the conclusion comparisons are made, by means of a series of figures, of the various parts of dinosaurs. Skulls are depicted of typical genera of such herbivorous forms as *Triceratops*, *Claosaurus*, *Camptosaurus*, and *Diplodocus*, giving the brain-cavity in position, to illustrate the diminutive size of the brain in each in

proportion to the skull; the form of the brain-cavity seen from above is given, also casts of the brain seen from the side compared with the brain of a young alligator (see pl. lxxviii). The divergent forms of the teeth are likewise shown. The pelvic bones, fore and hind limbs, are similarly treated.

Restorations of the skulls, limbs, and entire skeletons are given of *Anchisaurus colurus*, *Ceratosaurus nasicornis*, *Brontosaurus excelsus*, *Stegosaurus ungulatus*, *Camptosaurus dispar*, *Laosaurus consors*, *Triceratops prorsus*, and of *Claosaurus annectens*; whilst of European dinosaurs we have restorations of *Compsognathus longipes*, *Scelidosaurus Harrisoni*, *Hypsilophodon Foxii*, and *Iguanodon Bernissartensis*. The palatal view of the skull of *Diplodocus longus*, given on p. 177, is very interesting, and with the figures in pls. xxv and xxvi, and pl. lxxvi, fig. 4, completes our knowledge of this very strange form. Plate lix, skull and lower jaw of *Triceratops prorsus*, taken by photo-process from the original, gives us a fine idea of the head, one-ninth natural size, of this marvellous giant.

This volume, interesting though it be, with its 84 plates and 110 pages of text, is but a first instalment to a much more elaborate work which the author has in contemplation to produce. We trust that health and strength may be spared to Professor Marsh to complete this large task, and we will accept the present Memoir merely "on account," for which we are indeed truly grateful, but, like Oliver Twist, we are still "asking for more."

II.—Movements of Beach Sand and Shingle.

In an article on "Littoral Drift" read before the Institute of Civil Engineers,[1] Mr. W. H. Wheeler discusses the origin and movements of the sand and shingle along sea-coasts. He maintains that the movements are practically confined to the tract between low- and high-water mark; that the contour of the sea-bed on a sandy coast, when covered with a moderate depth of water, remains in a stable condition; and that so long as the conditions remain the same, the form of the banks and depth of the channels are not altered by winds and waves. He is thus led to believe that channels can be effectively deepened and maintained on sandy coasts by the system of suction-dredging; that they will then remain stable and retain their depth. Moreover, harbours may be projected out from sandy coasts without danger of the entrance shoaling, provided that the piers are so placed as to derange the main set of the tidal current as little as possible, and are carried into a sufficient depth of water; and that where required, the supply of littoral drift is cut off by protective works along the coast.

If these views be true their great importance is obvious. In support the author points out that the main navigable channel to New York, which passes through the outer bay to the Atlantic, was obstructed by four long shoals, over which the larger class of vessels could only pass at high-water. Suction-dredging was tried;

[1] Proceedings, vol. cxxv, 1896.

the channel was deepened so as to give a minimum depth of 30 feet at low-water over a width of 1000 feet, and a year afterwards it was reported that no shoaling had taken place. Again, the sand-bar which lies at the junction of the Mersey with Liverpool Bay has been deepened by the use of suction-dredgers, and the channel so excavated has not only maintained its depth during the severe tests of the gales of two winters, but shows a tendency rather towards deepening than shoaling. Other instances are given.

The author believes that the mass of beach sand and shingle which travels along the coast is due entirely to the erosion of the cliffs (which may, of course, consist of hard rock or of ready-made sand and shingle), and is not derived from the sea-bed. Hence he is of opinion that the quantity of drift is limited, and that it may be entirely stopped or its movement controlled. He, however, thinks that vast deposits of sand and shingle in bays and sheltered places on the coast are due to causes which occurred in remote ages, and which are no longer in operation—we presume at the localities in question. Thus, in Morecambe Bay the sand-beds cover an area of 90,000 acres dry at low-water, and in the Duddon estuary they cover 9,000 acres. The Wash covers an area of about 157,600 acres, of which about 84,000 acres consist of sand-beds dry at low-water. It is quite true that rivers add very little to these accumulations, but the waste of the coast now or formerly bounded by cliffs composed of Drift sands and other deposits has no doubt led largely to these great marine deposits.

We would point out that salt-marshes are not exactly due to the drifting of alluvial matter along tidal coasts and to its settling in sheltered places, but rather to ordinary alluvial deposits being formed in a broad valley or estuary, bounded by higher ground that has on one side been subsequently worn away by the sea. The salt-marshes along the Norfolk coast were probably formed in this way.

On the whole, while agreeing that the main contentions of the author are supported by fact, we believe that agents now at work will account for all the phenomena without recourse to higher and more frequent tides as suggested by him.

Among the matters discussed by Mr. Wheeler, we may mention his conclusion that while wind and waves are the agents which operate in eroding the cliffs and producing the sand and shingle, the regular and continuous travel of the material along the coast is due to the wave-action of the flood-tide.

In conection with these views, we may refer to those of Mr. F. P. Gulliver, given in an article on "Cuspate Forelands,"[1] or headlands formed by beach shingle and sand, and also as delta deposits. He points out that when the supply of waste from the cliffs has increased beyond the power of the currents to immediately deposit it offshore, then transportation takes place alongshore, and the growth of forelands may take place by tidal- and ocean-current action. Ocean currents have but little effect on the inner shore-line, or that of the more protected coasts of bays, sounds, etc.; there

[1] Bull. Soc. Geol. America, vol. vii, 1896.

tidal currents are the preponderating force. In broad bays ocean currents, tidal currents, or local wind currents, may, according to circumstances, be the strongest. Upon the outer shore-line the ocean eddy currents are the most effective, while upon lakes and inland tideless seas the local wind currents are the most important factor. The method in which various cusps are formed is well illustrated, but the author's explanations are rendered perhaps a little difficult by an American tendency to introduce and coin new words. H. B. W.

III.—Elementary Palæontology: Invertebrate. By Henry Woods, M.A., F.G.S., Demonstrator in Palæozoology in the University of Cambridge. Second Edition. 8vo, pp. xiii and 296, with 112 figures in the text. Cambridge Natural Science Manuals. (Cambridge University Press, 1896.)

PROFITING by the rude blasts of criticism and the equally instructive but gentler experiences gained in teaching, the author has brought out a second edition of his "Elementary Palæontology," which is a great improvement on the first, which appeared three years since. The book has been materially enlarged, a greater number of genera are described, and references are given to one or more typical species in each genus. The results of recent discoveries, such as, for example, in the Trilobites and Graptolites, have been incorporated in the work. Another important addition is in the illustrations, which have been doubled in number. They have professedly been selected for the purpose of explaining the structural features in different groups, but in some cases, as in the Ammonites, figures of typical species are given, and the value of the book would have been greater if more figures had been inserted in the text. So far from figures of fossils tending to lead students from making use of actual specimens, we are disposed to think the contrary, for it is very seldom that beginners in Palæontology attempt to compare their specimens with mere textual definitions, though they will readily do this if the descriptions are supplemented by figures. Great pains appear to have been taken to ensure accuracy in the definitions, both of the larger and smaller groups, and to those wishing to follow up the subject, the lists of some of the principal palæontological works will be of much assistance. Within its limits this book is a very serviceable introduction to the study of Invertebrate Fossils.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 18, 1896.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On *Cycadeoidea gigantea*, a new Cycadean Stem from the Isle of Portland." By A. C. Seward, Esq., M.A., F.G.S.

The specimen described by the author was discovered a short time since in one of the Purbeck Dirt-beds, and is now in the Fossil Plant gallery of the British Museum. In the absence of any fructification, Buckland's generic name of *Cycadeoidea* is chosen in

preference to *Bennettites*, although in many respects the Portland stem is identical with *Bennettites Gibsonianus*. Externally, the surface is covered with rhomboidal areas separated from one another by a projecting framework consisting of the silicified ramental tissue, which thickly clothed the bases of the petioles. The peripheral portion of the stem afforded thin sections from which it was possible to investigate the anatomical structure of the leaf-bases and ramental scales. Internally, the wood- and pith-tissues have been entirely replaced by inorganic material. The author calls attention to the preservation of a prominent apical bud covered with narrow bud-scales and capped by a mass of ramenta. No indication is found of a lateral inflorescence such as characterizes *Bennettites Gibsonianus*, and the negative evidence suggests the occurrence of terminal reproductive structures. A comparison of this fossil with recent Cycads and Ferns brings out many points of close agreement with the former; and as regards the structure of the ramenta, evidence is afforded of an interesting survival of the closer resemblance which formerly existed between Cycadean and Fern-like plants. The stem is named *Cycadeoidea gigantea*.

2. "The Fauna of the Keisley Limestone.—Part II. Conclusion." By F. R. C. Reed, Esq., M.A., F.G.S.

The author describes the Ostracoda, Brachiopoda, Mollusca, Echinodermata, and Actinozoa of the Keisley Limestone. He gives a list of fossils from the Limestone, and indicates those species which occur in the Limestone of Kildare, the *Leptæna*-Limestone of Sweden, and Stage F, of the East Baltic provinces. As a result of his researches he concludes that the fauna has a thoroughly Ordovician facies; that it is closely comparable with that of the Limestone of the Chair of Kildare, and of the *Leptæna*-Limestone, and less closely with that of Stage F, of the East Baltic provinces; that its palæontological features point to its stratigraphical position being at the base of the Upper Bala, and that it must be regarded as the locally thickened development of a bed which is elsewhere in Great Britain very thin, or entirely absent, or represented by beds having different lithological characters and a different fauna; and that the fauna has certain unique characters which mark it off from all other known assemblages of fossils in Great Britain.

CORRESPONDENCE.

LIFE-ZONES IN THE BRITISH CARBONIFEROUS ROCKS.

Sir,—In the November Number of the Geological Magazine, the Report of the Committee appointed by the British Association to study the Life-zones of the British Carboniferous rocks, contains a list of the Committee, from which the name of Dr. R. H. Traquair, who has kindly undertaken to report on Carboniferous fish, is omitted. As our Report is likely to become known to workers largely through the medium of the Magazine, I should be greatly obliged if you would kindly insert this correction.

Cambridge, *December* 5, 1896. John E. Marr.